61

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THE JOURNAL OF ANATOMY AND PHYSIOLOGY

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CONTENTS.

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ADDRESS IN PHYSIOLOGY, delivered at the Meeting of the British Association at Nottingham, by PROFESSOR HUMPHRY, F.R.S.

IT is, I feel, no small honour to be called upon to preside over this section which represents the very highest branch of physical science. I say the highest branch of physical science because it has to deal with the highest and hardest of physical problems. The animal frame, which it is our work to investigate, stands at the summit of the great physical cone, with man at the apex, by whom it is, as it were, slung from heaven, in whom the material is worked up to the point of contact with, and made subservient to the purposes of the spiritual. Indeed so complex is the animal organism, so intricate and varied are the questions in physiology, that it is apt to pass out of the range of science, and become too much a matter of speculation and an object of mystery; so that there is some danger of its being degraded by the very difficulties and features which should really place it in the highest position among sciences.

Infinitely varied in its forms and structure, suited to every conceivable condition, where air, moisture and heat are present, yet developed from one simple type, composed of various elements combined in the most intricate manner, with endless modifications of mechanical, chemical, and electrical processes, besides others which it is scarcely possible to recount or observe, much less to comprehend, and which we group under the term 'vital,' the animal machine presents interests for every mind, puzzles for every genius, and challenges the whole army of science and philosophy, through all coming ages, to concentrate their fire and attempt even its outer works. Impelled by the irresistible impulse for knowledge, cheered by continual victory, we march, and not slowly, ever onwards, and value our laurels none the less because each fresh one tells of more that must be won, and shows the final goal receding as we near it.

Finding, as we do, that the animal machine is the resultant of

all the properties or forces of matter, combined and harmonized by that most mysterious of them which we call the 'vital force,' we claim as fellow-labourers the workers in every division of science, and watch with interest each discovery, knowing that, in whatever direction it is, it has a bearing, more or less direct, upon our own study, welcoming all, digesting and appropriating what we can.

Both as regards the ground, therefore, which has been already turned, and that which remains to be explored, physiology affords the grandest field for labour, and provides occupation for every faculty. In no other science, perhaps, do observation and reflection so distinctly stimulate and help one another. It is chiefly by clear reasoning, by induction from ascertained facts, that physiology is to be studied and advanced; and though a short flight into the regions of imagination, now and then, may show a beacon light and help us better to track the path of knowledge, the lights there seen are too commonly *ignes fatui,* exciting and misleading. Hence the study of physiology is one of the best exercises of the mind; and the greater appreciation of it as such is being shewn by the admission of it, slowly and cautiously, it is true, into our educational system. It is taking its place in our Universities; and I am convinced that it and the other branches of natural science will be found at least as suitable instruments for cultivating and strengthening the various faculties of the mind, particularly those of observation and reflection, as any of the more favoured educational subjects. In looking to the future of young England, and its prospects in the struggle—the hard struggle—I will not say for existence but for position, among nations that seems to be impending, one cannot but feel that very much must depend upon the effectual development of the mental faculties. It has been by force of mind and not by force of coal, that our country has been raised to its present height. We must look to the same power to keep her in the fore front of nations. It is not the Miantonomoh, it is not the needle-gun, but the mind that conceives and the energy that makes and wields them, which gains the victory. If, as I am sometimes disposed to think, the old educational soil, upon which so many generations have been trained, is in some degree wearing out, it will surely be none the less productive for the introduction of new elements. At any rate they will bring out fresh powers to meet the changing circumstances of the times.

For the higher reasoning, combining, and analytical faculties, abundant scope and exercise will be found in the attempts to unfold the laws by which we live, and move, and have our being; and full reward is given by the glimpses which, from time to time, we attain of the wondrous workings of creative power. As an illustration of this I need only mention the elucidation of the processes of develop-

ment, evincing as they do, a simple, uniform law, underlying and working out the vastly diverse forms and structures of vegetable and animal life. Surely the knowledge that the tough oak-plank, the blade of grass, the lion's claw, the contracting muscle, and the thinking brain, all emanate from simple forms which, so far as we can tell, are perfectly alike, and, further, that the entire plant or animal also emanates from a simple form or cell which is undistinguishable from the rudiments of its several parts, is as full of interest, and as suggestive of high thought as any one of the fragments of knowledge which man has worked out for himself in the whole range of physical science; and what better exercise can there be than that of tracing the operation of the great law of uniformity of plan from this simple starting point, and witnessing the manner in which it holds its ground through all the infinite modifications by which plants and animals are adapted to their several positions, and to one another?

I will not however detain you with this, but pass on to one or two other matters.

The microscope has lately been to physiology much what the steam engine has been to manufacture and transit. It has opened up new regions for observation and given an entirely new direction to our thoughts. The structure of the several tissues and organs has probably been made out as far as the present means permit, and we are occupied now in investigating their mode of formation and connection with one another. There seems much reason to think that they are more closely related, more continuous, than we have been in the habit of regarding them. There is now little doubt of the continuity of the nerve fibres and the nerve vesicles; and it is not improbable that the other or peripheral parts of the nerves are continuous with the several tissues among which they ramify, with the deeper prolongations of epithelium, for instance, with the elementary structure of muscle, and with the filaments of areolar tissue. The continuity of areolar tissue with serous, fibrous, and mucous membrane, on the one hand, and with the intimate structure of the various organs, on the other, is more clearly shown; and a very general and extensive continuity is thereby established. The cornea is continuous with the sclerotic, and so with the optic sheath and dura mater. Even epithelium, which we were wont to regard as a distinct external and easily separable sheath, is found to send its filamentary prolongations into the subjacent organs, which become blended with the areolar and nervous and perhaps with the lymphatic systems. The epithelium of the glandular tubes is, in some organs, undistinguishable from the cells which occupy the stroma. The blood-vessels, in many animals, are continuous with the areolæ of the tissues; and, in all, the

ultimate circulation takes place through the tissues, the nutritious fluid passing freely, to and fro, between their interstices and the interior of the capillaries, where capillaries are present. We are thus reminded of the fact that in their embryonic period the several structures, or the potential rudiments of them, were all blended in a homogeneous germinal mass; and we learn that though they have become differentiated they have not become entirely separated, but retain in their mode of connection, the traces of their common parentage and of their early continuity. Such a blending of ultimate tissue, as a remnant of embryonic condition, assists us to explain many things, such as the transfer of impressions and what we call sympathy, that are at present difficult to understand, and is an additional illustration of the simple method by which, in nature's works, great ends are attained.

We perhaps scarcely realize and appreciate the bearing of the fact, that all the various tissues are formed from a primitive, homogeneous, and continuous plasma, by the formation and individualization of 'portions,' 'centres,' 'masses,' 'cells,' or whatever we please to call them, and their development into structure. Attention has been directed almost exclusively to the formation and development of these masses and too little to the mode and degree of their separation; though the latter is a process little, if at all, less important than the former, and must be effected by something analogous to what we call absorption. Indeed, the work of absorption, or hollowing out, during the embryonic state is little less active than that of secretion or building up. We are familiar with its work in the formation of the areolæ and cavities of bone, in the removal of the parts of the iris and eyelids that do not become developed into permanent structure; but we are not perhaps sufficiently impressed with the fact that the various cavities, canals, and spaces in the interior of the body are due to the same process, and that the failure or arrest of it may be the cause of many of the so-called adhesions of serous and other surfaces, as well as of the imperforate condition of canals and of the union of parts that should be free.

The transition from the investigation of the fine processes of the animal organism to the consideration of the forces by which they are brought about is a natural, a necessary step, though, I need scarcely say, it takes us into a region where advance must be slow, and where difficulties seem almost insurmountable. We are probing here into the very deepest recesses of nature and inquiring into her closest secrets, and we feel ourselves almost to be

Children crying in the night,
Children crying for the light,
And with no language but a cry.

Yet cry we must; and in time we shall get some, though perhaps never a full, reply. Indeed, when the questions that here arise shall have been fully answered, when man shall be entirely satisfied as to the essential nature and the first causes of that which he sees; when these deep problems shall be worked out, when the penetralia of nature's temple shall be thoroughly explored, science will have told its tale, and the physical world will cease to afford its mind-arousing interest for us. Of such satiety however we need have no apprehension. Increasing knowledge only further shews our ignorance, that kind of ignorance, at least, which gives more stimulus to knowledge; and thus the acquisition of knowledge and the attendant consciousness of ignorance together carry us on till the time when we shall know as we are known.

It is quite clear that what we call CHEMISTRY, with its attendants heat and electricity, plays a most important part in the animal machine; and, probably, more information as to the nature of the organic processes is to be expected from their chemical study than in any other way. Especially is this so now that the subtle method of spectral analysis is beginning to be applied to organic research and with such success as to render it impossible to calculate what may be the results of the application of this exquisitely delicate test. We have found out that there is a very close relation between a complex atomic formula and the vital processes, the amount of chemical tension which is expressed by the former being commensurate with the character of the latter, and the amount of chemical change which takes place in the textures being commensurate with the activity of the vital processes. There seems good reason to believe that a muscular fibre is the container of a given amount of chemical force compressed by the medium of a high chemical formula and existing, therefore, in a high state of tension, that during its contraction the compressed force is set free by the decomposition of its structure, that is by the resolution of its component elements, chiefly by a process of oxidation, to a lower formula or a state of lower tension, at the same time that heat is evolved and electrical changes take place; though the latter are not yet distinctly defined. It is impossible, therefore, to avoid the application here of the doctrine of 'correlation of force,' which is being so clearly worked out in the inorganic world, and which seems to be the greatest advance that has for some time been made in our knowledge of the laws of matter. We can scarcely doubt that the chemical force which is set free during the decomposition attendant upon muscular action, whether it be by the decomposition of the nitrogenous or the hydro-carbonous elements or of both, is the equivalent of the contractile force that is evinced and of the heat that is evolved

In other words, a muscle may be regarded as the medium by which force is accumulated, rendered latent, or condensed in a condition of high chemical tension and is, from time to time, as occasion may require, set free and converted into muscular or contractile force and heat.

It seems probable that such is the case; and we may look for the more clear demonstration of it, with some confidence, as a real gain to physiology, inasmuch as certain of the animal functions will be thus withdrawn from the mysterious region of life into the more intelligible domain of science.

Not that we must make too much of this and be too proud, and assume that, because we are able to refer a little more of animal process to the ordinary phenomena of matter, we may relinquish the idea of a vital agency altogether. Let us remember that we really know very little of those phenomena, not much more than we do about life. Attraction and chemical affinity, heat, light, electricity, magnetism, and motion, are all expressions for forces, of the nature of which we are, and perhaps shall ever remain, ignorant. They may be, and probably are, modifications of one force, of one force showing itself in different ways; and it is something to arrive at this. It may be that life is another modification of the same force; and it will be something more to arrive at that. We need not shrink from such a result; but we have not yet attained to it, and have no right to prejudge that it is, or that it is not, and to quarrel with those who hold a different opinion. Suffice it to admit that there is still much in vegetables and animals that we cannot explain by reference to the ordinary laws of nature, and which we refer to another law or power and call it life. For instance, in the case of muscle just alluded to; though the state of chemical tension may explain much, still, we know not how that tension, that complex formula, is brought about, and we cannot approach to an imitation of it. We know not how it is maintained. We know not how the force so pent up is liberated and converted into muscular action. We cannot explain these phenomena, much less those of growth and development, by reference to the chemical or other properties of matter; and until we can, we must be content to fall back upon the additional mysterious agent 'life.'

So with certain other vexed questions which are, in some measure, allied to this one. Can, or rather does, any combination of the ordinary forces of matter ever lead to the phenomena of life? If they are proved to be correlative with the vital force it might seem that some show of probability would be given to such a view. But we must remember that for the manifestation of vital force a living being is, so far as our observation at present goes, absolutely necessary; that is, life has never been known without a living being, without

a form, without a medium for the exercise of the vital force; just as there is no manifestation of attraction, or heat, without the medium—matter—through which they act. Thus we are impaled upon the horns of the dilemma—life is not manifested without a living being or medium, and the medium cannot exist without life—a dilemma from which our knowledge of the properties of matter is, so far as I can see, unequal to rescue us; and our only refuge is in the admission of a creative power to which the medium and properties of life, in the same way as the medium and ordinary properties of matter, owe their simultaneous existence. We must allow this for the present, without reference to the future progress of discovery; and, without being seduced into that over-much wisdom which is another expression for folly, must be content to reason from what we know. Further observation may supply other bases for our reflection, and widen the area of our thoughts by showing that matter is endowed with properties which enable it to aggregate into living forms; but no sufficient ground for such an assumption has yet been given.

A subject for investigation, nearly akin to that last mentioned, and which may, perhaps, one day, tend to throw some light upon it, is the transition from life to death, a change which, under ordinary circumstances, takes place in the most delicate, insensible manner; so that it is impossible to say when and how life ends and death begins. I speak not of that rude and sudden termination of the body's life from disease or decay—that somatic death—which we usually associate with the word 'death,' but which is in nature comparatively so rare that it may probably be regarded as rather exceptional and abnormal than natural. I refer to the mode in which the parts of the ultimate tissue of the body become changed and cease to exist, a process so subtle as to elude observation and to prove that the boundary line between life and death is hard to define. Even in the instance of the cuticle, a structure comparatively under the eye, as we watch the transition of the spherical deeper components to the flattened forms of the superficial strata, and the disintegration of the latter, partly by external influences, we are at a loss to decide where living force ends. Indeed there seems to be no point at which that can be said to take place. And, if with regard to the components of it and the other tissues we assent to the view that their external or 'formed' parts are lifeless and their internal or 'germinal' parts are alone endued with living properties, we still have to ask where is the division between the two? Where does the 'germinal' or living end, and the 'formed' or lifeless begin, and how is the latter done away with? Clearly it is not by an abrupt disintegration or solution, but by some slow insensible process which savours rather of atomic change

than of destruction. Then, one is inclined to ask, if the passage from the living to the unliving condition be of this insidious, inappreciable nature, may there not be a converse of a like kind, an insensible origination of, or conversion into life and life's forms, going on somewhere in the far recesses of nature's womb. I do not think we are bound to shut out the thought of such a possibility. It seems a fair question to entertain; but admitting it as a question, we must refrain from the tendency to give a hasty answer in the affirmative.

Granted, therefore, for the present, that the medium, the living form, was given or created with the vital property, does it remain the same in kind through all succeeding generations? or is it capable of undergoing changes, slowly and gradually, or, perhaps, if needs be, more rapidly, so as to adapt it to various circumstances and conditions, so as, in short, to evoke, in time, the diverse forms which animal life is known to assume; or must each of those forms have been the result of a special creation similar to that which we suppose in the first instance? One might have judged this to be a question which a careful examination and comparison of the different species, and the circumstances under which they are found, would have enabled us to decide with tolerable ease and certainty. But it has been found that it is not so. On the one hand, we see changes in each individual, whereby the complete being is evolved from the simple germ, changes that are suggestive of a corresponding evolution of the varied animal forms from one humble beginning. We find all the different animals emanating from the same point as a centre—the simple germ which presents precisely the same features in them all. We find them all carried along the same high-road of development and diverging to acquire their respective peculiarities; so that certain structural types are largely traceable among them, binding them together and suggestive of a common origin. We can arrange them in gradational series, not one series but several, of which one culminates in man. We find each animal so suited to its position and so surely disappearing when the conditions cease to be favourable to it, and as a necessary consequence of the alteration of those conditions, as to suggest that it was modified from a common standard not merely *for* but *by* the conditions which surround it. The records of the earth's history prove this adaptation to have been the case in former times as well as now, the faunas varying in correspondence with the variations in the surface and climate and temperature of our planet; and we can clearly prove certain modifications in species to be caused by changes in the external conditions in which they have been placed. Moreover, by attention to external circumstances and selection in breeding, we can induce deviations in the offspring and so imitate, it has been suggested, the process that goes on in nature.

These, with some other considerations, coincide with our scientific yearning to unfold the plan of the universe and trace in its growth and the development of its parts the operation of natural law. They seem to give us hints as to the mode of construction of the animal kingdom, which it is the legitimate work of physiology to gather up and weave into a consistent theory according with some new conceptions of creative plàn.

But, on the other hand, so high a point on the hill of knowledge —a point imagined rather than yet seen—can be but slowly reached. Much labour is required to clear away the thickets and level the ground, lest the springs of genius carry us down rather than up. Much observation must be made and much evidence accumulated before we can see our way to a theory of transmutation of species. The only valid, but it is a cardinal objection to such a theory, is the want of evidence that a change of the kind inferred really takes place and that so little proof of it is forthcoming in spite of the attention which has, for many years, been anxiously directed to the subject. The nearly allied species tantalize us by a certain flexibility of type and by their near approach to one another; but they seem rigidly to abstain from the boundary lines; and the variations that take place seem to have no especial reference to an approximation to those lines, but rather to a certain power of accommodation to external circumstances necessary for the preservation of the species. We find considerable varieties in the human species. We do not clearly yet know how to connect even these with one another or with a common origin. Some of these are more, some less allied to the monkey; but between the lowest of the human and the highest of the monkey there is a gap, the width of which will be differently estimated by different persons, but so wide that there has never yet been any doubt to which side any specimen should be referred. Now, if the one has been transmuted from the other, how comes it that the series has been broken and the connecting links ceased to exist. The conditions are still favourable to the existence of the man and to the existence of the monkey; why are they not still favourable to existence of the species that have connected the one with the other?—we may wonder, not only that the traces of species in *past* time are not forthcoming, but that the species are not *now* living. Moreover, we do not know that any conceivable conditions, operating through any number of years, would bring the gorilla or chimpanzee one whit nearer to man, would give them a foot more capable of bearing the body erect, a brain more capable of conceiving ideas, or a larynx more capable of communicating them. It is possible that such changes might be effected. One would fancy it probable; but we have at present too little right to assume it; and

the more extended the research without increasing the evidence the less does the probability become.

Neither do I think that much direct assistance has been given by the theory of NATURAL SELECTION based upon the STRUGGLE FOR EXISTENCE, ably propounded after long and careful research and ably defended as it has been. It has dispersed some of the fallacies and false objections which beset the idea of transmutation of species and has so placed the question in a fairer position for discussion; but it reminds us forcibly of some of the real difficulties and objections. Though artificial selection may do much to modify species, it is rather by producing varieties than by drawing away very far from the original stock. To the former there seems no limit; but the latter is stopped by the increasing unproductiveness and unhealthiness of the individuals, by the susceptibility to disease and the tendency to revert to the original type. So that increasing departure requires greatly increasing care; and we do not know that any amount of care and time would be sufficient to produce what might fairly be called a new species. The bringing about any marked change by nature's selection is shown to be very hard of proof, and has opposed to its probability the fact that the members of a species which are most unlike have the greatest tendency to pair and are the most fertile; so that we have here, in addition to the ready reversion of modified breeds to the original stock, a law by which the growth or perpetuation of peculiarities is prevented and a constancy given to the characters of the species. This law is more striking from its contrast with the bar that exists to the pairing of different species and the infertility of hybrids. Within a given range dissimilarity promotes fertility. Beyond that range it is incompatible with it.

These and other considerations have always inclined me to the opinion that modifications of animal type, occurring in nature, are more likely to be the result of external agencies operating upon successive generations, influencing their development, their growth and their maturity, than of 'natural selection' and 'struggle for existence.' But greater effects of these and other similar agencies must be shown before we ought to admit the evidence of their power to work out the great changes that have been attributed to them.

In pondering over the definiteness of animal types, so marvellously elaborated from a simple form, their slight variability through long periods, the clear manner in which they, many of them at least, are marked out from one another, and which increasing investigation seems to render more and more apparent; the prospect of proving that they are educed from one another by any of the hitherto

supposed processes seems to grow more and more distant, and the feeling arises that there must be some other law at work which has escaped our detection.

We are familiarized with the fact that in the inorganic world combinations take place only in certain definite proportions, for instance, that oxygen unites with nitrogen in one proportion to make nitrous oxyde, in a second proportion, a multiple of the first, to make nitric oxide, and so on to the fifth proportion or multiple, which gives nitric acid, and that between these five several fixed proportions no combinations take place. So that the resultants of these and other similar combinations—the inorganic species, as we may call them—are remarkably constant and fixed in their characters. Each has its one form, as in the case of a crystal of chloride of sodium, or sulphate of magnesia, which may be broken down or dissolved but which cannot be modified or made to approach, still less to pass into, any other form.

May there not be something analogous—some corresponding law of combining proportion—presiding over living matter, educing the various forms, fixing their characters, giving them constancy, in fact, evolving and fixing the species and preventing or hindering their transmutation?

It will be understood that I am not speaking of the combining proportions of the elements in the several animal tissues, which we know, or have every reason to believe, to be as fixed as in ordinary inorganic matter, though the combinations are more complex and the formulæ are, in consequence, harder to work out. I speak now not of this, but of something comparable with this and suggested by this, operating, not upon individual particles, but on masses, regulating, not the chemical composition and form and features of the tissues, but the form and features of the animal. As oxygen unites with nitrogen only in the definite multiple proportions represented by the figures 1, 2, 3, 4, 5, and under certain circumstances, producing, in each instance, a special compound unlike any other and marked off from the nearest approaching compounds by distinctive features and without any intermediate gradations: so, in the animal and vegetable world, the combinations requisite for evolving living beings may be regulated in a similar manner, taking place only in certain fixed proportions and under certain circumstances and educing certain definite forms, each of which is unlike any other and is marked off from its nearest approach by clearly distinctive features and without intermediate gradations. As each chemical compound (say nitric oxide) remains in its given condition, without change, till circumstances have culminated to favour and induce a change, which then takes place, not by slow gradation, but by sudden

start, to some other definite compound (say nitrous or nitric acid): so the several animal forms may remain fixed till the conditions for a change, which conditions may be external to themselves, are complete. Then the change may take place, and, not by slow gradations, but by sudden start, by something resembling a new creation, other definite and clearly distinct forms or species, be produced. Thus, as complementary and similar to the laws of 'uniformity in design' and 'variety in detail,' we may suppose to work on together the laws of 'gradation' and 'interruption;' by the one the living ladder is shaped and bound together, as a whole; by the other the steps are preserved distinct, *i.e.* the individuality of the species is given and retained.

At any rate, whatever be the law and forces which effect and regulate the evolution of species they are probably of the same kind as those which are operating in the inorganic world. The orderly and definite manner in which forms and features and specific characters are given and preserved in the one instance may be assumed to be of the same nature as in the other; and we must probably refer the fixed animal and vegetable types to influences identical with or similar to those by which the forms are assigned to crystals, and the stratification is given to rocks, by which the geological epochs have been determined, and the boundaries of our planetary and solar systems have been set. One cannot but think that it may be within the power of man to work out and to comprehend, in some degree at least, the principles by which these breaks in the organic and inorganic works, constituting as they clearly do an important feature in the plan of creation, are brought about and regulated.

The pendulum of opinion on this great question—the question of working by general law or by special interferences—may be expected long to swing to and fro ere it rests upon a settled conclusion. In the meantime it will help to keep the wheels of science going and add fresh knowledge to our heap.

And let us not shrink from the free, bold, fair discussion of these and other kindred subjects, under an apprehension that they are calculated to lower the religious element and shake the faith. Such discussions, and the thoughts which give rise to them, are a necessity, an inevitable result of advancing science, which it is as impossible to stop as the progress of time itself; and that which is inevitable must be accepted. 'Twould show a want of faith to resist it. Knowledge may be man's trial; but that applies to knowledge of all kinds, of that which is esteemed good as well as of that which is esteemed evil. Certainly the fruit of its tree brings responsibility; but responsibility is man's highest dignity, and opens one of the avenues to the tree of life. Theological zeal and scientific zeal are both good, and

representatives of good elements in man's nature—the element of faith and the element of thought. Both should co-operate in the work of purifying and elevating the character; indeed the one cannot advance safely without the other. Still they will, now and then, come into collision and threaten to undermine one another, needing forbearance and discretion to restore their harmony. One cause of the occasional outbursts of the *odium theologicum* is, I think, due to a fault on the side of the theologians. Not satisfied with, or distrusting, the really unassailable position on which their fortress stands, with its foundations deep laid in man's consciousness and God's work, they have endeavoured to raise outworks on the shifting ground of natural science, by drawing arguments from analogy, by associating special views of creation and resurrection with true religious belief, and by insisting on certain literal interpretations of the physical medium through which spiritual truth has been conveyed to us. Hence each unfolding of the material laws is liable to be regarded with suspicion, lest it should sap the foundations that have been thus unwisely propped. Religious arguments drawn from the physical world are very liable to prove two-edged swords cutting both ways according to the manner in which they are wielded, or staffs that penetrate the hands of those that lean upon them. Theology may rest safe upon her own position and watch with confidence and satisfaction the advancing waves of science, feeling assured that, though they may beat at times rather roughly upon her, they will soon calm down under her leavening influence, and simply add to and strengthen her soil.

And we may work patiently on, not pressing hastily to conclusions which our aspirations seem to point to, but relying on careful observation and honest reasoning to give us a solution of some of the great problems which animal life presents.

It will be perceived that the 'law of interruption' as I have called it, is quite compatible with a 'derivative hypothesis' of organic being, and even with the 'law of continuity' so ably traced in the inorganic and the organic world by the president of the British Association in his inaugural address at Nottingham. It takes cognizance of and would explain the groupings into 'masses,' 'strata,' 'series,' 'systems,' 'classes,' or by whatever terms we may indicate the natural divisions which form so prevalent and important a feature in the universe that we cannot ignore them, while it admits the possibility of sequence, or succession, pervading the whole. There unquestionably

are interruptions in the organic series; they are patent wherever we look. Some are more marked than others. There are many things to suggest an underlying continuity; and the work we have to do is to reconcile the interruptions with the continuity, and to show how the various species have been derived from one another, or from a common origin, supposing, as most physiologists are now inclined to do, that such is the case. Has this been done by a gradual transition? and if so how and why have the intermediate links disappeared? or have the changes been more sudden, and have gaps or interruptions, corresponding with those we now see, existed through the several stages of animal life up to this period? The data for the answers to these questions are probably forthcoming. The keen and extended enquiry of the present age may supply them; but they do not seem to me to be sufficiently accumulated and sifted to justify confidence in present convictions.

OBSERVATIONS ON THE COMPARATIVE MICROSCOPIC ANATOMY OF THE CORNEA OF VERTEBRATES[1].

By W. H. LIGHTBODY, M.D. Edinburgh.

1st. IN MAMMALIA. The cornea is a peculiar modification of the white variety of connective tissue, with certain superadded structures, viz. a structureless or elastic lamella, pigment cells, two layers of epithelium, capillaries, lymphatics and nerve-elements; these structures, in the different divisions of the Vertebrata, vary more or less in their development, in the proportion which they bear to each other, in their arrangement, and sometimes in their intimate structure. As a rule, they are all present, but now and again one or more may be absent.

Until lately the cornea has been considered a structure *per se*, distinct from the tissues surrounding it, and set in the sclerotic as a watch-glass in its frame: that this view was erroneous was pointed out first by Schwann, but was by no means soon acknowledged. I believe that some do not as yet adopt it, though it is very easily shown by a vertical section through the apparent junction of the cornea and sclerotic, when the rounded, confusedly inlerlaced bundles of the latter, with its irregular, stellate, corpuscular elements, will be seen disentangling themselves, becoming by degrees flattened, ribbon-like and tolerably parallel, the corpuscles elongating or rather becoming also flattened, and so in a vertical section showing only, or little more than, their edges. From their lying between the bundles in the cornea they appear in more or less continuous rows.

The relation between the cornea and sclerotic, as far as their optical properties are concerned, is just the same as between the transparent and opaque "troubled" varieties of rock crystal: in each transparency is due to the free transmission of light, in each an arrangement of the component particles, causing reflection irregularly in the substance, and so preventing free passage to light, produces opacity; but I hardly think that this is a difference sufficient to justify the rejection of the cornea as one variety of connective tissue.

Lamellæ of the Cornea.—When a vertical section of the cornea of a mammal is examined, especially if it has been previously dyed, a laminated appearance more or less perfect is seen; this effect is given by a number of longer or shorter very flat ovals, mixed with

[1] This Memoir consists of extracts from a Thesis presented in April 1865 to the Medical Faculty of the University of Edinburgh, by whom a Gold Medal was awarded to the Author in August 1865.

a comparatively small number of long more glassy strips, aided by the arrangement of the corpuscles: the ovals are the transverse and oblique, the strips the longitudinal sections of the bundles. The former present a finely granular appearance, the latter have a glassy look, much resembling the structureless membranes.

The bundles are connected to each other by a gelatinous form of connective tissue, which varies greatly in quantity and consistence in different animals: in the rabbit it is abundant but hard; in the rat it is also abundant, but so soft, especially near the margin of the cornea, that if the conjunctival epithelium be scraped off rather roughly, it is squeezed out of place, and presents much the same aspect as Bowman's corneal tubes, which I believe are generally considered to be the artificial separation of the bundles.

This gelatinous substance is dyed by carmine, though not so deeply as the corpuscles and their processes which lie imbedded in it, yet deeper than the tissue composing the bundles: this last is hardly dyed at all, unless the solution of carmine is very strong; and what it does absorb then is tolerably easy to wash out.

The bundles do not lie on the same plane throughout their whole length, neither do they keep a straight course, but they pass under and over the neighbouring bundles, usually ascending or descending the depth of one or two bundles at a time, seldom more; their lateral curves, in the same manner are not sudden, seldom even approaching a right angle.

The bundles composing the posterior (inner) portion of the cornea are thicker, not so undulating or so tortuous as those forming the middle portion; and these again are far more regular than the most anterior lamellæ. These often present a very interlaced and undulating appearance; this is to some extent a natural arrangement, but often it is greatly increased during the preparation of the section.

This last occurrence appears to me to depend on three things: first, the cornea is part of a hollow sphere, with its parts arranged so as to have equal tension through its entire thickness in that form; when therefore the whole cornea is dried flat on a piece of glass, for the purpose of cutting sections, the outer layers will be relaxed, compared to the inner, and would naturally become wavy, as much as permitted by their attachments. In proof of this, when a third or a quarter only of the cornea is dried, the tension on the posterior layers being taken off, the anterior are allowed more liberty, and when cut into sections, there is generally less waving than in sections cut from the entire cornea.

Secondly, a blunt knife by cutting unequally may also produce it. Thirdly, if in mounting the section the glass cover is pressed down and then pushed to one side so as to produce a rolling movement,

the upper surface of the section may be pushed beyond the corresponding part of the lower surface, with the effect of increasing the irregularity.

The two last causes act of course on all the lamellæ, but more on the anterior, because, the bundles being smaller, there are more joints in a given space, and so more capability for motion is also present.

To the same cause is due the milkiness of the cornea after death; the fluids of the eyeball evaporating relax the tension of the cornea, especially of the anterior layers, the ready transmission of light from the one layer to the next is thereby interfered with, and opalescence is produced.

The peculiar transition of the sclerotic to the corneal tissue begins to show itself earlier behind than in front, so that the diameter of the inner surface is rather greater than that of the external, and the sclerotic is as it were bevelled to the inside: in a section of this part, therefore, parallel to the tangent, true cornea is seen to the inside, and true, or slightly modified sclerotic, on the outside. I think that this arrangement is for the prevention of false lights, which would be produced if the glistening sclerotic came close to the line of refraction; as it is, especially when pigment is developed in this situation, it acts as a diaphragm.

It is of course impossible to state with certainty what may be the length of any one of the bundles making up the cornea, but as far as I have been able to make out in the sheep, some of the bundles may be traced in a radial direction, for perhaps a third of the radius, as distinct and separate, then thinning off to nothing, losing themselves amidst other bundles, or dividing in the direction of either their thickness or breadth, and so giving origin to, or joining two or more bundles.

The bundles do not appear to have any special arrangement, but seem to cross each other in all directions, principally at acute angles; some few bundles, especially at the margin of the outer surface in some animals (sheep), seem to be arranged circularly; in man they are arranged radially at this point.

The bundles are composed of white fibrous tissue, the fibres of which are very closely agglutinated, and arranged perfectly parallel to the sides of the bundle, but in the horse some of the bundles have their fibres wavy like ordinary white fibrous tissue, but more flattened.

One great difference between this and other forms of connective tissue is the entire absence of yellow elastic tissue.

The number of bundles making up the vertical thickness of the cornea, in other words, the number of lamellæ, varies greatly in

different animals, also, though not to so great an extent in different individuals of the same species, especially with relation to age, appearing to lessen by the union of overlying bundles; as age advances the thickness of the bundles themselves being also increased.

This change seems to begin first in the middle lamellæ, and to proceed to each surface, but it progresses faster with the posterior layers than with the anterior, so that by adult life little difference is perceptible between the middle and posterior layers. I shall have occasion to revert to this again.

Corpuscles of the Cornea.—In the gelatinous substance connecting the bundles are imbedded the usual corpuscles of connective tissue, but they present in this situation a much more regular form than in most others.

In a vertical section they show as elongated "spindle-shaped" bodies, generally with a thickening or nucleus at some one or more parts; it may be with a few processes going off into the surrounding tissue.

In a horizontal section they present an irregular stellate appearance, with numerous branching processes, the principal of which go off in a quadripolar manner; most of these branching processes seem to lose themselves in the surrounding tissues, but the larger ones often appear to anastomose with the processes from neighbouring cells.

Towards the edge of the cornea these become less regular, first of all fusiform, and then identical with the corpuscles of the sclerotic: the superficial cells also in some animals, especially the Rodentia, have a different shape, very little body, but the processes very long, large, and freely anastomosing with each other, in a looping manner, something like the arteries of the mesentery.

They vary greatly in number in different animals, and are far more abundant in young than old corneæ; in fact, the cornea of the human fœtus of between 4 and 5 months' development is almost entirely made up of them alone, and very much resembles the skin of the same age. (Pl. I. fig. 1.)

At this age the greater number are mere oval bodies, not more than one in ten or so having processes, and the intervening substance, the future white fibrous tissue, is hardly present. By the eighth month the corpuscles are large, with several large processes, but with few small ones, the interposed tissue is also fully developed. (Pl. I. fig. 2.) Future changes seem to be, the increase and hardening of the white tissue, the disappearance of some of the corpuscles, and the development on the others of the fine processes.

In the adult cornea, particularly in aged persons, the corpuscles

of the middle and posterior lamellæ are few and scattered, while in the anterior layers, where active nutrition is still going on, for the production of the conjunctival epithelium, they are almost as numerous as in the mature fœtus. (Pl. I. fig. 3.)

Are the corpuscles of the cornea "cells"? I believe them to be as much cells as the white corpuscles of the blood; they do not seem to have any distinct cell-wall, but they seem to be masses of a gelatinous substance, "protoplasm" or the "germinal matter" of Dr Beale. This substance contains one or sometimes more nuclei, and pushes out processes into the surrounding tissue; it also seems capable of motion, within at any rate the space it occupies.

The movements which I here allude to are, I think, identical with those performed by the pigment granules in the pigment cell: thus if to a fresh cornea very strong acetic acid be added, and the uncut cornea be then examined so as not to interfere with the corpuscles in any way, the corpuscles appear to be all or nearly all spindle-shaped, and few or no processes are to be seen. If a cornea be then treated with weak instead of strong acetic acid, 8 or 10 drops to an ounce of glycerine, allowing the cornea to remain in for a considerable time, the protoplasm by degrees shrinks and leaves the wall of the cavity, it also becomes transparent, showing its nuclei, while the processes are also often very well seen, the whole then strongly resembling an isolated lacuna of bone.

Now for the same object to take two such very different forms, some kind of movement must have taken place. Recklinghausen describes another kind of movement in the corpuscles of the cornea, of the frog indeed; but what applies to this animal will, I think, in such a matter apply equally to mammals. He states[1], that if a thin section be cut from the cornea as soon as the animal is dead, and this examined, moistened with aqueous humour, and carefully prevented from drying, the corpuscles will be seen pushing out and drawing in their processes, and working their way about in the tissue, actually crossing the field of view.

Kühne also states[2] that "the protoplasm contained in these cells is capable of performing 'spontaneous' movements of an exceedingly torpid character, but gradually changing the form of the cell from the stellate to the fusiform shape, or the reverse."

"The excitation of an interrupted current of electricity, or of sudden changes of temperature, more rapidly effects the alteration in form."

Kühne's observations I consider are well corroborated by my

[1] Abstract in *Syd. Society's Year-book for* 1863.

[2] Abstract in *British and Foreign Med. Chir. Review*, Jan. 1865, page 226.

own; Recklinghausen's I have tried twice, but failed to see what he describes, very likely from inexperience.

Elastic lamina.—The posterior surface of the cornea is lined by a perfectly differentiated structure, easily separated from the rest of the corneal substance.

This structure has gone by a great number of names, such as "Basement Membrane of the Aqueous Humour," "Descemet's Membrane," "Membrane of Démours," "Structureless layer," and "Posterior elastic lamina."

As some of these names indicate, it is a membrane on which the epithelium of the aqueous humour is immediately placed; it presents no determinable structure under the highest powers of the microscope, usually appearing glassy, rarely somewhat granular, it cuts very crisply, sometimes showing a series of longitudinal lines, as if it were made up of very fine lamellæ, at others vertical striations similar to those seen in stiff jelly when cut; it is also very elastic considering its thickness is so small.

This elasticity is shown in two ways. In the first place, it has a strong tendency to curl up with its corneal surface inwards, when separated from the cornea; secondly, when it is cut or pricked it retracts on all sides, making an aperture far larger than the instrument used. It resists the action of most if not all reagents, such as chromic acid, acetic acid, caustic potash and soda, (unless nearly saturated solutions) absolute alchohol, and boiling water; it is deeply dyed by carmine[1]. It is often thicker at the margin than in the centre of the cornea, sometimes indeed very much so.

It is generally described as terminating just outside the margin of the cornea, by dividing into three parts; of these, the innermost passing to the iris forms the "ligamentum iridis pectinatum;" the other two separating from each other enclose the "circular venous sinus" or "canal of Schlemm," and are then lost in the substance of the sclerotic. This account I consider erroneous, firstly, because the cases in which there is a ligamentum pectinatum iridis seem to be the exception rather than the rule, and of these in some I think the process belongs to the iris and not to this membrane; secondly, because I have never as yet seen any sinus in this position. I shall have occasion, when on the vascular arrangements of the cornea, to point out where the venous sinus really occurs.

The true description, I think, would be that it terminates just beyond the margin of the cornea by becoming fibrous, which fibres are lost in the areolar tissue, which is the anterior termination, or point of attachment, of the ciliary muscle. In some animals free

[1] Would Dr Beale for this reason call it "germinal matter"?

processes, either entirely fibrous, or partly fibrous and partly composed of the same structureless tissue as the membrane itself, are sent off from its free surface to the iris, while the greater part goes on and ends as in other animals. There is a remarkable exception to this description in the seal, in which animal at the point of transition of the sclerotic into cornea, a bed of tissue closely resembling tendon on section is interposed between the cornea and the elastic lamina: this bed is thick towards the sclerotic and ends in a rounded form, towards the cornea it rapidly thins and ends in a sharp edge. The elastic lamina sends into this structure five or six digitations, which are sometimes branched and end in slightly clubbed extremities, while a small portion passes on to the areolar tissue in front of the ciliary muscle.

The function usually ascribed to this membrane to maintain the proper curve of the cornea is, I think, an insufficient explanation of its use; for I do not know that it ever forms a $\frac{1}{50}$th of the thickness of the cornea, sometimes $\frac{1}{500}$th, or even less; for example, in the seal this membrane just inside the edge of the cornea is only $\frac{1}{4000}$th of an inch, while in the centre it thins off to $\frac{1}{12000}$th of an inch. Now the cornea of the seal is rather, though not excessively thick. From the habits of the animal it will have to support very sudden changes of external pressure: if then the preservation of the curvature of the cornea depended on this layer, we should expect to find it under such circumstances unusually thick, but it is just the opposite: on the other hand, in the sheep and horse, animals both having very thick corneæ, well able to maintain their own curvature, especially as they have no abrupt changes of external pressure to undergo, this membrane is exceedingly thick.

The means by which the curve of the cornea is maintained, I believe to be the tension of the eyeball, kept up by the due secretion of aqueous and vitreous humours.

Another proof that the development of this membrane is not dependent on the curve of the cornea, may be found in the comparison of the corneæ of the rabbit and guinea-pig: they are both about the same size and thickness, that of the guinea-pig being rather the thinner; they are also about the same curvature, the rabbit being rather the flatter; yet Descemet's membrane in the rabbit is $\frac{1}{1000}$th of an inch thick, in the guinea-pig it is only $\frac{1}{4000}$th.

I think that it may have two principal uses; 1stly, preventing the too rapid absorption of the aqueous humour by the cornea; 2ndly, acting as a tendon to the ciliary muscle.

When I say that it may serve as a tendon to the ciliary muscle, I do not mean that the curve of the cornea is at all altered; tense as is the eyeball in a normal condition, this could hardly be effected by

such a muscle as the ciliary; all that I mean is, that it is the point of resistance for the muscle.

Descemet's membrane is much thinner in young animals than in adults; thus, in the human fœtus of from 4 to 5 months it cannot be distinguished; in the new-born kitten it is only $\frac{1}{8000}$th of an inch thick, in the nearly adult cat it is $\frac{3}{4000}$th of an inch thick.

Perhaps this is the best place to speak of a structure, described by Bowman and His, on the anterior surface of the cornea, analogous to the structureless membrane already described. Bowman, who was the first to describe it, speaks of it in the human cornea as a layer from $\frac{1}{1200}$th to $\frac{1}{2000}$th of an inch thick, very like the posterior elastic layer in appearance and characters, but much more intimately united to the proper substance of the cornea, by a series of "fibrous cords" passing down into the anterior layers. To this arrangement he attributes the functions of providing a smooth surface for the support of the conjunctival epithelium, and maintaining the curvature of the cornea.

His states that he has seen it in man, the ox, the sheep, the pig, the rabbit, and the guinea-pig, but not in the horse, goat, dog, or cat.

I believe this membrane, except perhaps in the human cornea, to be an optical illusion, caused in this way. The conjunctival epithelium is of different density and refracting power from the corneal tissue proper; their surface of apposition therefore forms a reflecting surface, from which the light is reflected through the anterior layer; more light in this way is sent through this layer in addition to that naturally passing straight through it, consequently it appears to be more transparent, more glassy than the other lamellæ, especially when not in exact focus. I have seen this appearance more frequently in the cats than other animals, and attribute it to the exceedingly regular manner in which the bundles in these animals are arranged, while in the rabbit, in which the anterior layers are comparatively irregular, and the external surface of the cornea proper not smooth, I have never seen it; but in this animal the corpuscles may occasionally be seen in close apposition to the epithelium.

With regard to Bowman's "fibrous cordage," in most animals (in all that I have examined except man, in whom they are much smaller and more numerous) they are the tracks of nerves. I had long suspected this, but had no proof (among mammalia at least); but fortunately one of my friends lately gave me the eyes of a mountain-hare: one of these I dried on glass and cut sections from, in some of which the "fibrous cordage" was well seen (Pl. I. fig. 4), marked out here and there by rows of yellow-brown fat globules; the other I prepared for the nerves, when I found that they were considerably

decomposed, and that many were resolved into the same yellow-brown fat globules as I had seen in the sections. On looking again at the sections, after some trouble I found two or three distinct "nerve-cells," such as I shall describe farther on.

The structure in man to which I have alluded as the only representative of Bowman's "anterior elastic lamina" that I know, is, I believe, a slightly modified form of the cornea itself, not a distinctly differentiated structure: it appears to be formed by the fibres of the anterior bundles of the cornea separating in a fan-shaped manner, inclining to the surface and then interlacing very closely, so that it presents a very finely granular look.

Corneal Pigment.—Just at the junction of the cornea with the sclerotic, and extending a small distance into the former, there are in many animals pigment-cells.

They are arranged in the manner of a diaphragm, projecting into the cornea, farther towards its anterior than posterior surface, and preventing by this disposition the passage of false lights.

They are situated with the cornea-corpuscles in the gelatinous medium connecting the bundles, when very numerous seeming to take their place. In structure they resemble the ordinary pigment-cells, and, like them, show evidence of the movement of the pigment-granules; as sometimes in the same animal they are seen with the processes very dark, while the body of the cell is clear, at others the body of the cell is filled with pigment, and the processes are barely discernible.

In form they may be distinct, or more or less connected together, stellate, fusiform, rod-shaped, or without any determinate form.

They are most abundant where there are vessels, but are wanting in albinos of course, in whom however vessels are present. They rarely project far beyond the capillaries, but I have twice seen them near the centre of the cornea, in which cases they took a comparatively regular stellate shape.

Epithelium of the Cornea.—Each surface of the cornea is provided with a covering of epithelium. The epithelium of the anterior surface is a slight modification of the ordinary epidermic epithelium, prolonged over the cornea from the conjunctiva: it is composed of several layers of cells; of these the deepest are rather elongated, resting on the cornea proper on their ends; the next are about equal in their length and breadth, and from thence to the surface they gradually become more and more flattened, until at last they are nearly as thin as the outer cells of the epidermis; their nucleus however always remains distinctly visible.

This coating varies in thickness in different animals; it is also often thicker at the margin than in the centre. It seems to me that

it is the last-formed portion of the cornea, and that it grows over the cornea from the margin, for I have specimens from the new-born kitten, showing it pushed over the cornea about the $\frac{1}{50}$th of an inch, while the rest of the cornea is bare. That it could not have been removed by maceration, is proved by the same section showing the epithelium of the aqueous humour; the other cornea shows vessels and nerves.

The other layer of epithelium is that of the aqueous humour; it is supported directly on the elastic lamina, and consists of a single layer of nucleated cells placed just touching each other, not crowded: they are as thick in the young animal as the adult, but perhaps not quite so large; in the newborn kitten this layer and Descemet's membrane together are about $\frac{1}{2000}$th of an inch thick, of which the membrane forms only about the fourth part.

It has been described as exceedingly perishable; I have not found it so: it may nearly always be found if looked for within three or four days after death; and I have found it in a cornea that had been in spirit for two months, and in a human fœtus that had been dead for a week. The object-glass used has a great deal to do with its visibility.

Nerves of the Cornea.—Although it is thirty years or so since Schlemm discovered nerve-fibres in the cornea, comparatively few observers appear to have directed their attention to them; the only names that I am acquainted with as having published anything about them since Schlemm's discovery, being Rahn, His, Kölliker, Ciaccio, Kühne, and Beale: others, though they did not see them, were mostly content to take the sensibility of this part as an evidence of nerve-fibres being present in it.

It is singular that they should have been so seldom seen, for acetic acid by itself will show them in many mammals and birds, and in some reptiles. The process that I have found most successful is as follows:

Let the conjunctival epithelium be removed from a perfectly fresh cornea very gently. This is best done by acting on it with caustic potash for a time, varying with the thickness of the layer, but the shorter the better; it can then be removed by passing the edge of a blunt knife over it with as little pressure on the cornea as possible. The potash must then be carefully washed away, and dilute acetic acid added, to neutralise any remaining potash, and so prevent it acting on the cornea, and make it take the dye more easily; this is then washed off, and a very weak ammoniacal solution of carmine is put on and left, with occasional stirring, until a light and uniform tint is given. The carmine is then washed away, and strong acetic acid added; the effect of this is watched at very short intervals, and

as soon as the nerves are tolerably well seen it is run off, and a mixture of equal parts of glycerine and camphor-water added. The specimen can then be mounted, either in this medium, or, what is in some respects better, in glycerine-gelatine.

If the cornea be very thick it is better not to act much on it with the strong acetic acid, but to put it into strong glycerine to which a little acid has been added, and leave it there for a fortnight or more before attempting to make any sections from it.

If possible, in preparations for the nerves the whole cornea should be mounted in its thickness, for horizontal sections, however carefully made, always destroy a great number of the nerves. When sections are absolutely necessary the cornea should be soaked in glycerine for at least four days to harden it, and then the slices cut with a very sharp knife dipped in glycerine. It is sometimes an advantage to dye them in a solution of the carminate of ammonia in glycerine, after the process of Dr Beale.

The precautions to be observed in preparing the nerves are, 1st, to procure fresh corneæ; 2ndly, not to allow the caustic potash to act so long as to reach the cornea proper, as it at once destroys the finest fibres; 3rdly, to use the cornea throughout with the utmost gentleness; 4thly not to dye too deeply; lastly, not to act too long with the strong acetic acid, as it disintegrates the nerve-fibres.

I have succeeded sometimes in displaying the nerves by the use of a magenta dye, but it seldom does so well as carmine, and very soon fades away.

If a cornea cannot be mounted at once it may be preserved for some time in the strongest glycerine: I have mounted some tolerably successfully which had been kept for two months. Spirit does not do well; it soon makes them granular, and if they are fine destroys them.

The nerves of the cornea seem to be derived from the ciliary nerves alone; though I do not say positively that none come into it from the conjunctiva, yet I have never seen any in spite of many trials.

The ciliary nerves pass forward in the grooves in the sclerotic. When they reach the ciliary muscle they divide into two sets of branches, one of which goes to supply this muscle and the iris, the other set passes yet more forward and is distributed to the cornea.

This set may again be divided into two, the superficial and the deep; of these the superficial are usually much smaller and pass outwards to the surface, dividing as they proceed. When they reach the margin of the cornea they are very near the surface, all being contained in the anterior fourth of the thickness, and the trunks are few, composed of more than two fibres, and by far the greater number are entirely resolved into single fibres.

The deep set are much larger than the superficial, and do not divide so much, so that they reach the margin of the cornea still as large trunks: their place of entrance is about the middle of the thickness, occupying perhaps the middle third.

No fixed number of nerve-trunks appear to enter the cornea, though Dr Ciaccio seems to consider that each animal has a definite number; but, according to my observations, they vary, not only in different animals of the same species, but in the two corneæ of the same individual, both inversely to the number of fibres in the superficial layer, and to the size of the trunks themselves; for when these are large the number of trunks is small. Having reached the cornea the trunks become excessively hyaline, from the loss of the white substance of Schwann, of which only a very thin coating can be seen, just after the entrance of the nerve; it also disappears very shortly; many of the fibres are without even this, and the solitary superficial fibres are entirely without it, being reduced to the axis-cylinder and a prolongation of the membrane containing the white substance of Schwann.

The number of fibres composing the trunks varies greatly, from 2 or 3 up to 20, or perhaps in some animals more, but it is impossible to say, from the size of a trunk, what number of fibres it may contain, for the fibres become imbedded in much the same kind of gelatinous substance as that connecting the bundles of the cornea, and this varies greatly in amount, and also fibrillates under the action of acetic acid. Thus I took notice of a trunk in the cornea of a dog, after I had removed the epithelium, and saw distinctly that it contained three fine dark bordered fibres, well separated from each other; after tinting and treating with acetic acid, the same trunk looked as though it contained 10 or 12 fine non-medullated fibres, but its distribution only showed three fibres.

The trunks do not enter the cornea at regular intervals; they are, I think, rather more numerous at the sides of the cornea than at the top and bottom, often also a comparatively large part of the circumference may be found, without any entering trunk; a large trunk near will then be found to bend aside, follow the curve of the margin, and, giving off branches from its concave side, supply the deficiency.

Sometimes a trunk immediately on entering sends off a branch to a neighbouring trunk (generally a weak one), which thus reinforced, passes on to its distribution, or a trunk may divide into two parts, and both join other trunks.

Having entered the cornea, the fine superficial nerves at once begin to be distributed, by forming a polygonal meshwork between the bundles composing the 3 or 4 anterior lamellæ, occasionally

coming right to the surface so as to be covered only by the epithelium.

This meshwork is more or less close according to the animal, and is formed by the division and union of the fibres; at nearly every, I believe at every, point of division or junction there is an enlargement, usually triangular, but often quadrangular or multangular, according to the number of fibres meeting at that point.

These enlargements I consider to be true nerve-cells, in fact, they bear a strong resemblance to the cells of the spinal cord; they were first seen, I think, by Ciaccio, and were called by him "peculiar bodies." In structure they consist of an investing membrane continuous with the membrane of the fibres, and contents, which during life perfectly transparent, are coagulated, and rendered granular by reagents.

If the specimen has been successfully prepared a vesicular nucleus may be seen in many, often in one of the angles (Pl. I. fig. 6); occasionally two nuclei are met with, particularly in those cells that have more than three angles; they appear sometimes to contain also a little pigment.

The cells are exceedingly thin, and are placed usually parallel to the surface of the cornea, not often at right angles or very obliquely.

The superficial nerves forming the meshwork pass inwards for perhaps half the radius, meanwhile the deep trunks passing in form also a network, but a very much coarser one than the superficial, and as they pass in, they proceed towards the anterior surface of the cornea, which they reach somewhere about the middle of the radius.

The network of the deep nerves is formed in a different manner to the superficial meshwork; the trunks divide usually by the mere separation of their fibres into two or more smaller trunks, which in their turn divide until the fibres become single; the branches of one trunk often unite with those of another.

Occasionally, in some animals frequently, one of the fibres of a trunk, at a point of division, is connected with a large nerve-cell, and sends a fibre along each trunk. The solitary fibres also pass into large cells where they divide, the fibres going off being generally smaller than the fibre joining the cell, and also generally going to the surface.

These large cells are the same in structure as the smaller ones belonging to the superficial set, but they are very usually polyclonic; an irregular triangular pyramid is not an unusual shape, but they may have six or seven poles; they are also much thicker than the small nerve-cells, and are often placed vertically.

By the time that the deep nerves reach the anterior lamellæ, about the middle of the radius, they are reduced to nearly the same

size as the superficial nerves; these they then join by means of the nerve-cells, and they together carry on the meshwork to the centre of the cornea, the nerves from all sides helping to form the meshwork here.

Throughout the whole of this meshwork no free ending of a nerve-fibre is ever found, at least in a well-prepared cornea; moreover, nerve-fibre always passes into nerve-fibre through the medium of the nerve-cells; they certainly never become connected with the cornea corpuscles. Ciaccio was the first to point out this distinctly, nevertheless Kühne has lately written as follows: "Near the centre of the cornea the axis cylinder becomes very pale, varicose, and connects itself with one of the caudate prolongations of the stellate cells[1]."

I think that Kühne's own words show why he fell into this mistake; he describes the nerve-fibre as "varicose;" I suspect from this, that he examined either corneæ that were not fresh, and consequently the nerves partly disintegrated, or sections and specimens which had been too roughly used.

A properly and successfully prepared fresh cornea shows the nerve-fibres between the cells almost like fine threads of glass. My own observations in respect to the relation of the fibres to the stellate cells fully bear out Ciaccio's statement, that "the only relation the nerve-fibres bear to the corpuscles of the cornea is that of contiguity."

I have said that I believe that at every point of division of one fibre, or of junction of two or more fibres (by junction I mean not mere apposition, but the actual fusion of the one with the other), there is an enlargement which from its structure and aspect, as well as from its connections, I regard as a true ganglionic nerve-cell. Their universal presence has, I think, not yet been recognised; for Ciaccio, the most recent writer on the subject, though he recognises their occurrence, seems to regard them as comparatively rare, and figures nerve-fibres dividing without any enlargement whatever. I believe him to be wrong here, because, seeing their presence so very general, I was induced to re-examine the apparent exceptions, and I found that with higher powers I could see many cells that had escaped me before, particularly as my eye became educated.

Still there were some that defied all means to demonstrate a cell; but I think that these may be explained, some by the cell being vertical instead of horizontal, others by two fibres running in close contact, and then separating.

I may remark, that a lens with a large angular aperture is of

[1] *British and Foreign Med. Chir. Review*, Jan. 1865, page 226.

considerable advantage, when the fibres are fine, and when the cells are very hyaline, a $\frac{4}{10}$th of 55° showing many of both that a $\frac{1}{4}$th of about 38° could either not show at all, or but faintly.

Very large polyclonic cells are sometimes seen in the superficial meshwork; these may perhaps be formed, sometimes at any rate, by the coalescence of two or more ordinary cells with three or four poles. I have a specimen from the rat showing a large cell with five fibres going off from it, and a large oval hole in the middle, showing evidently that it is composed of five triclonic cells. (Pl. II. fig. 1.)

In the large triclonic cells of the deep nerves, where a tolerably thick trunk appears to merge itself in a single cell, and to give off only two fibres, is this to be taken as evidence of there being only one fibre in the supplying trunk? In other words, can two fibres of the same trunk go to form one cell in that trunk, and have only two fibres of distribution?

I have seen, on one occasion, in the guinea-pig a large cell, with apparently but one fibre passing to it from the periphery of the cornea, whilst two fibres proceed from it towards the centre of the cornea, each of which soon divide with an ordinary cell at the point of division; yet the granular contents of the large cell were distinctly divided into five masses, each of which almost seemed to have a nucleus.

All the fibres given off by one of the ordinary cells of the superficial meshwork are pretty nearly equal in size; but occasionally we meet with a cell, one or all of the fibres of distribution of which are very much finer than the ordinary fibres, a fifth to one-tenth the size. These fine fibres it is difficult to trace for any distance, seldom even to a distinct termination of any kind: very rarely indeed I have succeeded in tracing them to another cell, either to an ordinary one, or to one bearing the same proportions to an ordinary cell as these fine fibres do to the other fibres.

These fibres and cells I am at present inclined to consider as atrophied, their functional life being ended; but they may prove possibly to have some relation to another system of nerves, which I shall mention farther on. Connected with the trunks, especially with the larger ones, may be seen a few small fusiform nuclei, which appear to belong, most of them at least, not to the nerve fibres, but to the tissue they are imbedded in: they become rarer and rarer as the trunks become smaller, and in the superficial meshwork are very scarce.

I have never seen the nerve-fibres in the meshwork with any nucleus involving their substance; very rarely a small nucleus may be seen adherent to the one side, but the fibres themselves pass from cell to cell, round and highly refractive, maintaining a tolerably equal diameter throughout.

These nerves are, I believe, nerves of ordinary sensation, and such has been the general opinion of observers with one exception, Dr Beale. This gentleman, in a paper published in the *Micros. Journal for* 1864, page 13, considers them to be capillary nerves, and that they only convey sensations of pain in morbid states of the cornea, usually influencing the nutrition of the cornea. Now I do not deny that they may influence nutrition, but if they do so, the power must be extended to all other nerves of ordinary sensation; and that these are such I think is shown by the great pain produced when a small portion of the corneal epithelium has been scratched off. There is another set of nerves in the cornea much more closely resembling Dr Beale's "capillary nerves," and such I believe them to be; to these I now turn.

Among Dr Beale's numerous observations on nerves, he has described a plexus of excessively fine, non-medullated nerves, ramifying on and among blood-vessels, even to the terminal capillaries, illustrating his observations by reference to the palate of the frog. In the course of my study of tissues in general, I repeated his observations, confirming them as far as I could with the powers at my command; and then turned to the cornea, in which, first in the sheep, and soon after in the rat, after some time I found nerves around, and in the immediate neighbourhood of, the capillaries, in essential particulars bearing a close resemblance to those in the palate of the frog.

In the rat these nerves are very distinct in appearance from the ordinary nerves before described, and present a great contrast in size, the ordinary nerves average in diameter from $\frac{1}{6000}$th to $\frac{1}{8000}$th of an inch, while the capillary nerves average from $\frac{1}{16000}$th to $\frac{1}{21000}$th of an inch, some running so fine I believe as $\frac{1}{30000}$th, though I never was able to get a good measurement of them, one I could rely on, with the micrometer I use. (Pl. II. fig. 2.)

In the sheep they are much more numerous than in the rat, from the capillaries being so much more numerous; but the distinction between them and the ordinary nerves is less obvious owing to the much greater fineness of these last compared to those of the rat, while the capillary nerves are of about the same diameter. (Pl. III. fig. 2.)

Perhaps a better name for these nerves will be tissue nerves; for they occur in the tissue surrounding and at some distance from the capillaries, as well as in their immediate neighbourhood.

These nerves follow much the same arrangement as the ordinary nerves, in their terminal plexus.

A moderately thick fibre ($\frac{1}{5000}$th of an inch in diameter say) enters the cornea in the neighbourhood, and on a level with the capillaries; it is usually single. Once I have seen one separating from a trunk of ordinary nerves; sometimes it enters in close proximity to the vessels,

but these are usually surrounded by fibres already forming their terminal plexus.

From this it will be seen that, like the sensor plexus, the meshwork formed by these nerves is supplied from two sources, namely, nerves that have already become functionally active, (for I consider that a nerve is not functionally active until it has reached its terminal expansion,) in the sclerotic, and nerves that enter the cornea before they become so. These last very soon on entering the cornea become connected with a cell, the fibres which go off from this are perhaps $\frac{1}{12000}$th to $\frac{1}{16000}$th of an inch in diameter, and very likely each divides again, and then joins the plexus of nerves that have already divided, ramifying above, below, and around the capillaries; also in the space of the loop, many pass beyond the limits of the capillaries, continuing to form a plexus for some distance, but one with more open meshes. Finally, this plexus seems to send off long comparatively straight fibres, which may be sometimes traced a long way, being at last lost sight of; sometimes they seem to terminate in the cells of the sensor nerves.

Whether this appearance be a deception or a fact, and whether the very fine fibres, which I have mentioned as occasionally seen among the ordinary fibres, have any connection with these nerves, I am not prepared to say. The meshwork formed by these nerves is supplied at the points of division and union with cells proportioned to the diameter of the fibres, so that the cells of the first and second division frequently show their nucleus; but in the majority this cannot be seen, especially the very small cells that may be found on the curious sheath which the capillaries possess.

My reasons for regarding these nerves as distinct from the nerves that have been before described, may be gathered from what I have said. They are, briefly, difference of size in fibre, cell, and mesh, and difference in position, being so very abundant round the capillaries; in fact I have only seen them numerous in animals that have the corneal capillaries very well developed, to wit the sheep and rat.

I believe them functionally to be referable to the vasomotor system, taking this name in a wide sense; for as capillaries are not considered usually to be actively contractile, and if they are, as these nerves are distributed beyond the capillaries, it would be absurd to call them vasomotor in a strict sense; in other words, I would transfer Dr Beale's idea of the function of ordinary nerves to these, or to part of them, and attribute to them the office of influencing the nutrition of the cornea, in a reflex manner acting on the vessels supplying it.

Vessels of the Cornea.—The vascular arrangements of the cornea consist of capillaries and lymphatics, which bear a very intimate relation, the one to the other.

The blood-vessels are capillaries only, large and small; I have never seen an artery passing into the true cornea. In most animals the ciliary and sclerotic arteries are the source of the whole supply; but in the horse, dog, and perhaps man, a few capillaries pass in from the conjunctival vessels.

The capillaries form round the margin of the cornea a network of loops, with the convexity of each loop towards the cornea: they vary greatly in their development; some animals have no capillaries in the true cornea, the loops occurring in the transitional portion between the cornea and sclerotic; while others send single loops, or large compound tufts, far into the cornea, every gradation being found between these extremes.

The capillaries usually pass into the cornea at about the fourth of the thickness of the cornea from the front, and in many animals this is the only place of entrance; but in others a few also enter just in front of the elastic lamina, and in very thick corneæ also between these.

In the many healthy corneæ I have examined, I have never seen the capillaries passing farther into the cornea than perhaps one-fifth the radius.

Even the human fœtus of the 8th month shows no sign of capillaries farther than the adult; and the new-born kitten, with its capsule of the lens and *membrana pupillaris* beautifully vascular, shows the capillaries of the cornea ending in loops a little inside the margin as plainly as the full-grown cat.

The blood passing from the cornea is collected by large capillaries, and poured into a large vein that surrounds the cornea at some distance outside its margin. (Pl. III. fig. 1 *a*.) This is the circular venous sinus of Schlemm: it occurs at about one-third the thickness of the sclerotic from the outside, not, as it is often described, where the elastic lamina loses itself; an artificial separation is very easily made in this situation, which has, I suppose, given origin to the idea of the sinus being in this place.

The blood from the sinus is carried off by four or five large veins which pass backwards in the substance of the sclerotic, join the choroidal veins, and then emerge. (Pl. III. fig. 1 *b*.) In structure these capillaries resemble others, consisting of a membrane with scattered nuclei, well shown by caustic potash; their walls are not attached to the corneal tissue, but they are quite free (the greater number at least) to swell out and collapse, according to the amount of blood contained in them, as will be shown in the description of the lymphatics.

When the cornea is irritated, capillaries are frequently formed, which afterwards atrophy, and they atrophy in this manner: the vessel contracts at the loop, and at last is obliterated; and the contrac-

tion progresses along the two capillaries forming the loop, so as gradually to shorten them, the free ends thus formed being pointed; beyond the point and along the sides of the vessel the corpuscles of the cornea are seen to be altered in form, being fusiform, and larger than usual; the capillary itself is of greater diameter than the ordinary ones. (Pl. II. fig. 3.)

I had long been looking for lymphatics in the cornea without success. I had also long been familiar with an appearance round the capillaries of the cornea of the rat, resembling a very loose nucleated sheath, which I regarded as a sort of channel in the corneal tissue, larger a good deal than the vessel, so as to allow the vessel to dilate and contract freely, according to the amount of blood needed by the cornea, which of course being a firm hard tissue would not admit of ready dilatation, if the vessel were immediately in contact with it on all sides. (Pl. II. fig. 2.)

Some time after I first noticed this appearance, I was examining the cornea of a rat, from which I had partly removed the epithelium, and in it I noticed large rounded vessels forming loops at the margin, in the same manner as the capillaries usually do in that animal: these vessels appeared full of a fluid containing a good deal of granular matter, and a few colourless round cells, I naturally at once set them down as lymphatics. Unfortunately I made no drawing of them in this state, thinking that they would be plainer when fully prepared; but in the subsequent manipulations most of the contained fluid was forced out, and they then presented the appearance I was already familiar with, with the exception of two or three loops, which still kept some of their granular contents, but had no capillary inside. If these were lymphatics, what relation did they bear to the capillary? They had not the appearance of accompanying the capillary as the *venæ comites* accompany an artery, and no division, or fenestration, was seen such as Dr Carter has described (*Medical Times and Gazette*, September 1864) in the arrangement of the lymph-vessels accompanying the arteries of the liver. Neither could it be said that the lymphatics were simply superimposed on the capillaries. The most probable explanation of the appearance was that the capillary was enclosed within the lymphatic.

This explanation I was very unwilling to adopt, as I had never heard such a relation mentioned, and I did not see how nutrition was to go on, according to the ordinary ideas; also, though I examined a great number of rats and other animals, I never again saw the same appearance of large vessels filled with granular fluid. I began to think therefore that I had been mistaken in calling them lymphatics, and to revert to my original idea of a sheath, and to consider that the appearance might be due to the cornea (though it seemed perfectly

normal) being in an incipient state of inflammation, and so exudation poured out into the sheath. A little after this, while examining the nerves, which I have described as capillary or tissue nerves, in the sheep, I was struck by the frequency with which rows of rounded nucleated cells occurred along one or both sides of the capillaries. (Pl. II. figs. 5 and 6.) These bodies were smaller and more regular in shape than the corpuscles of the cornea, moreover they possessed no processes; and a membranous sheath similar to, but not so strongly defined as that in the rat, was also usually seen enclosing them.

At the root of the tuft of capillaries the same rounded bodies were seen often, in very great abundance, surrounding the capillaries; but occasionally a large vessel, two or three times the size of a capillary, with excessively thin walls, was to be seen, not enclosing any blood-vessel, but with a considerable number of the same bodies in it; in fact, but for these cells, the vessel would have been almost or quite invisible; very usually the cells were collected in the vessel in a mass, crowded and rounded towards the cornea, scattered towards the sclerotic (Pl. II. fig. 5 *b*); beyond the mass the vessel might with great difficulty be traced a little way, but from its excessive tenuity no determinate end could be made out, though it often seemed to go on to a capillary and join the sheath.

The round bodies or cells seen in these situations precisely resembled the white corpuscles of the blood, in size, in being nucleated, and in being granular and rough. I connected this appearance with that which I have just referred to in the cornea of the rat, and regarded it as additional evidence in favour of the view that the capillaries were enclosed within lymphatic spaces. Shortly afterwards my attention was directed to a paper by Professor His (*Siebold und Köllikers Zeitschrift* 1865) in which he describes "perivascular spaces" surrounding the vessels of the brain and spinal cord, which he was able to inject, and from them to fill the lymphatics of the meninges. This observation gives me additional ground for believing that the arrangement I have described in the cornea must be referred to the lymphatic system. I have also tried to inject these vessels, but from the unfavourable nature of the tissue in which they lie, have only once succeeded, and that to a very limited extent; but I consider the evidence afforded by the presence of lymph-like corpuscles in them better than any injection. I have seen similar arrangements in every cornea that shows the vessels, in the mammalia and birds, also in the iris of the pigeon. (Pl. IV. fig. 1.)

I believe the lymphatics do not terminate in the same way as the capillaries. Not unfrequently in the rat an offset may be seen stretching beyond the capillaries into the cornea, and being lost there; also long, straight, structureless fibres may be sometimes seen

passing from them across the cornea, from which other shorter fibres spring at right angles; these, from a specimen which I have from the pigeon, I believe to be lymphatics without contained capillaries.

These vessels seem to have an exceedingly fine membrane with a few scattered nuclei, as their sole constituent; it is attached to the corneal tissue pretty firmly, but still is free enough to fall into folds when relaxed.

In calibre they vary very much; when the capillary is fully distended with blood in the sheep it nearly fills it, leaving perhaps a quarter vacant; in the rat they are very much larger; they may often be found in the sclerotic.

When capillaries are developed anew by irritation, the lymphatics are also developed very largely, especially the free trunks.

If the nerves, that ramify plentifully in the outer portion of the sclerotic coat of the human eye-ball and the lax areolar tissue on it, are carefully examined, peculiar rounded or oval bodies will be seen connected with them, hanging on to them like a cherry on its stalk; for at the first glance but one fibre can usually be seen, going to each, but with a power of 400 or more diameters, several additional fibres often come into view. (Pl. V. figs. 2, 3, and 4.) These bodies I believe to be ganglionic nerve-cells, similar to those described by Dr Beale from the sympathetic in the abdomen of the frog; I also think that they are nerve centres belonging to the "vasomotor" system, taking this word in a wide sense and making it include the motor nerves proper and the tissue nerves.

My reasons for this opinion may be gathered from the following short account of them. They are rounded or rather spherical bodies, varying in size from $\frac{1}{500}$th to $\frac{1}{2500}$th of an inch in diameter, possessing a membrane which is very lax and wrinkled, which also shows a few nuclei; the contents appear to be granular, and a central more opaque portion is often visible.

The larger cells have usually one nerve-fibre possessing a medullary sheath going to them, which generally loses its sheath of white substance a short distance from the cell and proceeds as the axis cylinder alone; the smaller cells have usually no such fibre.

In addition to the dark-bordered fibres the larger cells have one or more, frequently four or five, very fine fibres passing away from them; these are nearly always arranged in a spiral manner to each other and the large fibre. They are often nucleated, and sometimes divide dichotomously, with a small triangular enlargement at the point of division.

Generally all the fibres pass from the same end of the cell, but sometimes when the cell is oval or very large, a few pass from the opposite end as well.

In the small cells fine fibres alone are as a rule to be seen.

The fine fibres may accompany the large fibre, and join the nerve-trunk it comes from, these trunks being generally composed of dark-bordered and fine fibres, or they may pass to their distribution as an independent trunk of fine fibres alone.

Now these fine fibres, when they can be followed to their distribution, are found to form a plexus, similar to that seen in the skin of the frog, in the palate of the same animal, and also to that of the tissue nerves of the cornea. These bodies are to be found as far forward as the ridges surrounding the margin of the cornea, here they are of the smallest size with only fine fibres; I think it not improbable that those found in this situation may be connected with the tissue nerves of the cornea itself.

It might be suggested that these bodies were "tactile corpuscles," but their structure does not resemble that of the touch bodies I have seen nor yet of the Pacinian bodies; moreover, the touch bodies occur in papillæ, and in parts that are used for touch, not in parts where the perception of pain is all that is necessary.

I may say, as making my opinion of their nature more stable, that I have seen, in immediate connection with the larger nerve-trunks in the palate of the frog, cells identical in appearance with those found in the abdomen of this animal. I have as yet seen these structures in man only.

2nd. In Birds.

The cornea in the majority of birds presents an entirely different aspect to that of mammals. In a vertical section it seems like a single thick lamina of a slightly granular substance, with a number of fusiform corpuscles imbedded in it; this is the appearance shown by birds such as the swallow, thrush, titmouse, finches, wren, robin, magpie, lark, parrot, &c. (Pl. IV. fig. 2.)

In the Raptores the cornea is much the same as in mammals, being composed of tolerably large bundles arranged at right angles to each other, and interlacing very regularly as if woven; the corpuscles are numerous and are placed very uniformly among the bundles, which are very thick in proportion to their breadth. (Pl. IV. fig. 1.) I think that the cornea of other birds is formed exactly in the same manner, but the bundles are very small and closely united, while the corpuscles are not so numerous and are arranged in an entirely different manner.

In those birds first mentioned the corpuscles are small, on a surface view round, with several branching processes, which show a tendency to a quadripolar arrangement: in a vertical section they are

seen to be arranged in two principal layers, the thickest of which is near the anterior surface, close to it in some birds, as the starling and wren; with a more or less broad band of corneal tissue, void of corpuscles, between it and the surface in others, as the swallow, linnet, magpie, parrot, &c.: this anterior layer of corpuscles often occupies $\frac{1}{4}$th of the thickness of the cornea.

The thinner layer is immediately in front of the elastic lamina, it often consists of only two layers of corpuscles, sometimes of only one, as in the robin. Between the two layers are found only a few scattered corpuscles, the comparative number varying greatly; there are but one or two in the lark, while they are rather numerous in the parrot.

In the Raptores there is none of this grouping of the corpuscles; they are more numerous in the very anterior layers as in mammals, but they occur uniformly, and very plentifully throughout the rest of the thickness of the cornea; in these the vertical section hardly shows any processes to the cells, in the other birds plenty may be seen.

There is the same change from sclerotic to cornea in birds as in mammals, but in the small birds it is very abrupt and often not very clear; in the eagle, on the other hand, it is as distinct as in mammals.

Descemet's membrane is always present, but is exceedingly thin; in the eagle it is but $\frac{1}{8000}$th of an inch thick, and in most birds not half so much; in fact we should usually not be able to recognise its existence at all, but for the way in which it is thrown into folds when the cornea is laid out flat; it passes entirely to the areolar tissue on the inside of the sclerotic, never providing the iris with a ligament.

The conjunctival epithelium is always well developed, the cells often show their nuclei very clearly: the epithelium of the aqueous humour is not often seen.

The cornea of birds, especially of the smaller ones, is most plentifully supplied with sensor nerves; they are very distinctly divided into a deep and superficial set, and are much finer than the same nerves in mammals, the most superficial being frequently as fine as the tissue nerves in the sheep, though, owing to their much greater refracting power, and to the transparency of the cornea, they are far more readily seen, and they are also less interfered with by the corpuscles.

The general description of the sensor nerves already given under the mammalian cornea answers very well for those of birds; but the meshwork is more irregular and closer, the cells very seldom show any nucleus, and many places of division, or of apparent division, are visible, which show no indication of an enlargement. The small size of the nerves, and their much more frequently ramifying in a vertical

direction, (as seen in sections) may I think account for much of this last difference.

I have said that the superficial nerves are very fine; they are also very near the surface, consequently they are very often destroyed; and until lately I was ignorant of their existence, having mistaken the meshwork between the deep nerves and these superficial ones for the terminal plexus, as these intermediate nerves are both fine and abundant.

The same method answers for the preparation of the nerves of birds as for those of mammals; but very great caution must be used with the potash and manipulations.

The nerves vary in development in different birds; they are strong and numerous in the finches, not so strong but more numerous in the lark; comparatively few in the wren, titmouse, magpie, &c.: in the eagle they are tolerably numerous, the fibres fine, the cells small, the meshes large, and very usually more or less regularly rectangular.

In birds, generally, the large trunks enter the cornea often very near the posterior surface, and do not reach the surface until the centre of the cornea.

Capillaries are very seldom seen. As a rule they do not extend beyond the pigment, which surrounds and hides them; when they are visible they are seen to have a very thin coat indeed, and are arranged in a very close and intricate network, each capillary sheathed in a lymphatic, which is very distinct when the capillary is only moderately distended. (Pl. IV. fig. 3.)

I have only seen capillaries in the pigeon, eagle, greenfinch, and titmouse, in these two latter only once out of many corneæ; the pigeon is far the best to examine, in it many of the capillaries form little loops of a single capillary twisted on itself and standing up free into the conjunctiva; these show the lymphatics very plainly, as when looked down on, each loop looks like an oval cell with two strongly defined round nuclei, merging into a single indistinct oval one when the top of the loop is brought into focus. (Pl. IV. fig. 3 *a*.)

I have also seen in the pigeon, in the cornea itself, narrow vessels with very ill-defined walls filled with granular matter; they occur as a group arranged in a rectangular manner lying at some distance from the edge of the cornea, a single larger vessel leading away from them to the edge of the cornea, where it joins another group of similar vessels; there are also a few isolated portions as it were around the edges of the first group. I am inclined strongly to look on these vessels as lymphatics; but whether this is the normal arrangement accidentally engorged, or a pathological production, I am not prepared to say; but at present I regard the former as the more probable.

I have never seen any tissue nerves in birds.

3rd. In Reptilia.

Of this class I have only examined the tortoise. My remarks, therefore, will be confined to this animal.

The general structure of the cornea of the tortoise is between that of mammals and fish; the lamellæ are thin and well marked, the corpuscles small and few, but pretty regularly scattered through the whole thickness. The bundles are very broad, and have almost lost their individuality, blending with their neighbours by their margins; they are also arranged, as in birds, at right angles to those that occur immediately above and below them.

I have never seen the corpuscles other than fusiform; and they also are arranged principally in two directions, one at right angles to the other.

The sensor nerves are very large and strong, with the cells well marked, and pretty numerous. (Pl. III. fig. 3.) The Greek tortoise has many more nerves than the box tortoise; but they are larger in the latter, especially the cells. In the latter also the deep trunks are large; in the former a trunk is a rarity.

The pigment-cells do not form a regular border to the cornea, but occur as groups pushed in here and there; in the Greek tortoise these groups are moss-like in appearance; in the box tortoise they are in the form of distinct fusiform cells crossing at right angles. The capillaries are few but very large, forming a network something like that in birds, but simpler; I have not been able to distinguish any investing lymphatic, but it by no means follows that they do not exist, as my specimens are unfavourable.

Tissue nerves I have not seen in the reptilia.

4th. In Batrachia.

In the frog, the only animal of this class I have had an opportunity of examining, the structure of the cornea is precisely similar to that of the tortoise, except that Descemet's membrane is nearly twice as thick, that is $\frac{1}{8000}$th of an inch.

The conjunctival epithelium is very beautiful, the cells distinct, and the nucleus very evident.

The corpuscles are rather larger than those of the tortoise, and very often look as if fusiform; but their real shape is stellate, as is very well seen in a cornea acted on with nitrate of silver during the life of the animal.

The sensor nerves I can say little about, for they are very difficult to bring out, and none of my preparations being really satisfactory, all that I know at present is that the trunks are very large,

the fibres fine and very loosely arranged in them, and that they anastomose as trunks of considerable size, forming a coarse network all over the cornea; at the points of division or union there are sometimes, I think, to be seen triangular cells connected with one of the fibres, but they are very difficult to make out: Ciaccio describes them in this situation: the fibres sometimes appear to divide in the trunk with very small enlargements, they also leave the trunk as single fibres; but I have been unable to trace them far from the place of departure, and so know nothing of the terminal expansion.

Pigment is very abundant round the cornea, the cells being very irregular, with short thick processes.

Capillaries are very sparingly supplied, and I have never seen them beyond the pigment, so that any lymphatic there may be is hidden, but the vessels of the sclerotic show the investing lymphatic tolerably well.

Tissue nerves I have not seen in the cornea, but they are plentiful in the sclerotic.

5th. In Fish.

In this class my observations have been almost confined to the cod and conger eel.

In fish the cornea (taken in a wide signification) is in appearance an entirely different structure to that of the previously described classes; there is no conjunctival epithelium; instead, the skin of the body passes over the eye, and is modified into a structure closely resembling cornea, being made up of fibrous layers laid down at right angles to each other, with corpuscles between them. It is united to the cornea proper by a very soft, gelatinous, mucus-like connective tissue, which in the cod is very distinct, less so in the conger eel, and hardly to be seen at all in the trout. In the cod it is divisible into two layers, the inner of which is thinner, softer, very full of oil, and not so firmly laminated as the outer.

The true cornea is attached to the sclerotic, and is a modified form of it, as in mammals, &c.: in the cod, in which the sclerotic is chiefly made up of a cartilaginous plate, the cornea takes a fibrous origin almost altogether from the edge of the plate, and the outer surface close to the edge.

In structure the cornea is made up of layers, which can be torn off almost entire; they are blended with each other near the edge, and are fibrous, the fibres of one being at right angles to the fibres of the contiguous ones.

In the vertical section of the cornea of the cod the fibres of those lamellæ which are cut across show a fibrous structure. The

fibres apparently pass vertically, and along with them a great number of strongly refracting granules of small size, some indeed very small, are seen. (Pl. VI. fig. 2.) Those layers which are cut in a longitudinal direction show some granules, but no vertical fibrillation. Between the layers of the cornea is a soft gelatinous tissue containing a few corpuscles, which swell out enormously under acetic acid.

There is no proper Descemet's membrane, that is, no structureless layer; but the innermost layer of the cornea is very fibrous longitudinally, whatever direction it is cut in, and I suppose is the analogue of that membrane.

There is much less difference between the skin and the true cornea in the conger eel than in the cod; in fact they are very like each other, except that the cornea has thicker, and not such regular lamellæ, and fewer and larger corpuscles. (Pl. VI. figs. 1 and 3.)

Sensor nerves exist pretty abundantly in the skin of the eye in the cod and eel: in the eel they are very evident and are precisely similar to the nerves of the rat: in the cod nerve-trunks ramify all over the cornea, principally made up of dark-bordered fibres, while a few single fibres may also be seen, and I believe make a plexus similar to that in the eel, superficial to the trunks; but the nerves in the cod are not easily prepared.

Are there nerves in the true cornea? In the eel there are a good number of nerves ramifying round the edge of the cornea, so the probability is that they extend into it; but I have not been able to trace them in this fish, much less in the cod. Capillaries also occur round the cornea, but sparingly; they are more abundant in the skin, but here do not go beyond the margin; they give indications of investing lymphatics, and long straight fibres are often seen passing from them far into, or even across the cornea; perhaps these are connected with the lymphatics.

Pigment-cells are very abundant round the skin, and are occasionally to be met with beneath it round the cornea; they are exceedingly beautiful in the cod, being mossy stellate cells when the pigment is expanded; in the eel they are of a rather peculiar shape, being rings of pigment.

PLATE I.

Fig. 1. Vertical section of the cornea of human fœtus of the fourth month.

Fig. 2. Vertical section of the cornea of human fœtus of the eighth month greatly swollen by acetic acid.

Fig. 3. Vertical section of adult human cornea.

Fig. 4. Vertical section of cornea of guinea-pig, showing the track of nerves simulating the "fibrous cordage" of the "anterior elastic lamina" of Bowman.

Fig. 5. Vertical section of the cornea of horse, showing numerous fine short processes passing from the corpuscles into the neighbouring tissue: also the curious wrinkling of the bundles in this animal.

Fig. 6. Sensor nerve plexus from the cornea of rat, showing nerve-cells with nuclei.

PLATE II.

Fig. 1. Sensor nerve plexus from cornea of rat, with a peculiar nerve-cell with a large oval hole in its centre, showing its probable origin from five triclonic cells coalesced.

Fig. 2. Vascular arch from the cornea of rat, showing the shrunken capillary invested with its lymphatic sheath, pigment-cells, and tissue nerves (Dr Beale's capillary nerves).

Fig. 3. Group of vessels undergoing atrophy, from the cornea of a rat in which a wound of the cornea had recently healed. Fusiform nuclei are seen edging the vessels and extending beyond their shrunken points; probably these belong to the lymphatics.

Fig. 4. General structure of a vascular arch of the cornea. *a.* The included capillary. *b.* The loose sheath formed by the lymphatic. *c.* The nuclei of this lymphatic.

Fig. 5. Portion of vascular network from the cornea of sheep, showing the capillaries surrounded by lymphatics; these are seen to contain lymph corpuscles. At *a* is seen a lymphatic without any included capillary, but with a great number of lymph corpuscles in it; these are aggregated very much at *b*, indicating very probably the place of a valve.

Fig. 6. Another capillary from the cornea of the sheep, showing its lymphatic sheath with corpuscles and a free lymphatic, *a.* At *b* this free lymphatic seems to have received a branch from the lymphatic investing the capillary, and probably one also from the left from a neighbouring arch.

PLATE III.

Fig. 1. Vertical section of the injected cornea of a kitten at the passage of the sclerotic in the cornea, showing

a. Section of the circular venous sinus of Schlemm.

b. An efferent vein passing backwards from the sinus, cut obliquely.

c. Iris.

Fig. 2. Plexus of tissue nerves from cornea of sheep.

a. End of a tuft of very small capillaries with investing lymphatics.

b. A nerve-trunk, probably containing three or four fibres, passing to supply the sensor plexus of the cornea. This trunk was considerably deeper in the cornea than the fine nerves.

Fig. 3. Group of nerve-cells from the cornea of box tortoise.

PLATE IV.

Fig. 1. Vertical section of cornea of golden eagle near the anterior surface.

Fig. 2. Vertical section of cornea of linnet, showing the manner in which the corpuscles are grouped in a layer near the anterior surface, leaving a clear space, *a*, at the immediate surface.

At *b* are seen nerves passing up to ramify in the superficial portion of the cornea.

The middle portion of the cornea is seen to contain but few corpuscles.

Fig. 3. Vascular network from the edge of the cornea of the pigeon, showing the investing lymphatic. At *a* is seen a loop, the top of which is out of focus, and so only the section of the capillary is to be seen.

PLATE V.

Fig. 1. A vessel teazed out of the iris of a pigeon, showing the investing lymphatic.

Figs. 2, 3, and 4. Peculiar bodies, probably nerve-cells, with a thick loose coat of areolar tissue, found connected with the nerves in the conjunctiva on the sclerotic immediately surrounding the cornea; from the human eye.

Fig. 2 has a medullated fibre which does not as usual lose its sheath before reaching the cell. Fine fibres are seen passing in three directions.

Fig. 3. A cell with no dark-bordered fibre, the trunk of fine fibres is seen loosely twisted, and one fibre separates itself immediately from the trunk, and at *a* begins to form its terminal plexus.

Fig. 4. A cell with but two fibres, one medullated and losing its sheath before entering the cell, the other a fine fibre distinctly twisted round the first.

PLATE VI.

Fig. 1. The skin of the eye in the conger eel modified to resemble the cornea. Vertical section.

Fig. 2. Vertical section of the true cornea of the cod, showing the layers of which it is composed, and large scattered nuclei lying between them.

a. a. Layers cut through longitudinally with the fibres.

b. b. Layers cut across the fibres, showing a vertical fibrillation and numerous granules.

Fig. 3. Vertical section of the true cornea of conger eel. Compare with Fig. 1.

ON HUMAN MUSCULAR VARIATIONS AND THEIR RELATION TO COMPARATIVE ANATOMY, by JOHN WOOD,

F.R.C.S. *Demonstrator in Anatomy at King's College, London; Assistant Surgeon to King's College Hospital.*

THE muscular system in man, and probably also in the lower animals, is subject to irregularities producing almost every variety of anomaly. From Albinus downwards these anomalies have attracted the attention of anatomists more or less powerfully. In the earlier times, when, for want of human subjects for dissection, such animals as apes, dogs, &c. were, perhaps, more commonly the subjects of investigation than they are now, the striking similitude of many of their muscles to the human variations occasionally found, has enforced attention on the observer. Such was the case, for example, with the *Sternalis brutorum* of Sandifort and Sabatier (1790). In later years, the gradual separation of the human from the comparative anatomist, and the specialization of their respective studies, have led probably to a less distinct apprehension of the relation of the varieties in the human system to the normal muscles of lower organizations. Numerous human abnormalities have indeed been recorded by Sharpey, Quain, Hallett, Macwhinnie, and Struthers, in this country, and by Meckel, Haller, Theile, Gruber, Gantzer, Rosenmüller and Isenflamm, by Luschka, Kelch, Wagner, Fleischmann, Otto, Cruveilhier, Henle, and others, in Germany and France; but these have usually been detached observations without special reference to the coexistence of other anomalies, or to the presence of similar muscles in animals. In this respect Meckel only may be considered as an exception; and even his extensive generalizations referred rather to the normal arrangement of the muscles in man, as compared to that of other creatures, than to the varieties met with in the human subject viewed in the same way. In this department of scientific anatomy I believe that I am not alone in thinking that much remains to be done by patient and detailed investigation; and if the results at all correspond to a reasonable anticipation, much light will be thrown from this quarter upon the interesting and much discussed question of the position of man in the animal kingdom, and his relation to his inferior fellow-creatures. If, in addition to the general resemblance of the muscular mechanism, there be found in the former fragmentary records of special apparatus which have, in the latter, the fuller development of a definite purpose, then these may be taken as at least of equal importance with other evidence of

traces,—some may think, of a general unity of plan with varied teleological intentions;—and others,—of an ancient morphological relationship of a much closer character. But if, on the other hand, muscles are found which have no place in the various animal types, we may fairly take them as indications, valuable so far as they go, of progress still advancing towards a higher development of the human frame—of an increase in the distance already great which separates physically man from animals.

The present paper is a small contribution towards the attainment of a definite conception of the degree of relationship which exists between man and animals in respect of a muscle not usually considered as being very subject to variation, viz. the *coraco-brachialis;*—also of another, of the occasional existence of which I have found no record in the authors I have up to this time been able to consult. The last muscle I have called the *Flexor carpi radialis brevis* vel *profundus.*

Coraco-brachialis.—In the human subject I have observed three varieties of arrangement in the fibres of this muscle, which I will give in the order of their frequency.

First. The muscle usually described as arising from the tip of the coracoid process, partly tendinous and partly muscular, in common with the tendon of the short head of the *biceps.* Many of its muscular fibres also arise from the hinder surface of this tendon of the *biceps* half way down to its insertion. The insertion is into the middle of the inner surface of the humerus opposite to that of the *deltoid* (fig. 1 *a*). This muscle is sometimes, but not, perhaps, so frequently has as been described, perforated by the musculo-cutaneous nerve.

Fig. 1.

Second. Another slip is not uncommonly found (*b*) more or less connected with the preceding at its origin. It is, however, more fleshy than the latter, is placed internal to it, and is generally connected by a lunated aponeurosis (*d*) with the insertion of the *pectoralis minor* into the coracoid process. Passing down the arm, sometimes in front of the former so as to conceal it, but usually a little to the inner side, this portion of the muscle becomes inserted into the upper part of the internal condyloid ridge of the humerus, partly connected

with the internal intermuscular septum, and partly with a distinct, white, shining ligamentous band with vertical parallel fibres (fig. 1 *d*), which reach down as far as the internal condyle itself, upon the upper part of which it is implanted. This band covers the ulnar nerve, and is distinct from and placed posterior to the true intermuscular septum, which lies deep between the *triceps* and *brachialis* muscles. Its fibres are most distinct above, where they can be traced behind the insertion of the *coraco-brachialis* as high as the lesser tuberosity of the humerus, crossing the tendons of the *latissimus dorsi* and *teres major* muscles. Below the insertion of the *coraco-brachialis* they approach gradually towards the true intermuscular septum, connected meanwhile by the aponeurosis of the arm, and finally become blended and implanted with it upon the internal condyle. The distinction between this longitudinal band of fibres and the true intermuscular septum seems to be recognized by Henle (*Muskellehre,* s. 179), but was first especially insisted on by Struthers (*Anatomical and Physiological Observations,* 1854), who traced it as high as the *teres major,* and proposed for it the name of the *internal brachial ligament.*

The last described portion of the *coraco-brachialis* is extremely variable in size when present. It is sometimes a very small slip, not conspicuous as a separate element of the muscle, from the upper part or bulk of which it is separated by a cellular interval, through which the *perforans Gasseri,* or *musculo-cutaneous nerve,* generally passes. In this condition it has been recognized by Theile (p. 215, *Jourdan's* translation of the *Cyclopédie Anatomique,* 1843). This author mentions also that the superficial portion is often found continuous with the fibres of the *brachialis anticus.* The same observation was made by Meckel (*Handbuch,—Muskellehre,* s. 498). When it is totally wanting the musculo-cutaneous nerve passes generally quite superficial to the *coraco-brachialis* muscle. When, on the other hand, this portion of the muscle is largely developed, as seen in the subject from which fig. 1 was taken, it may pass entirely superficial to and across the brachial vessels and median nerve, the tendon forming an aponeurotic opening for them between the first and last-described portions of the muscle, as they cross from the inside to the front of the arm. This arrangement has also been described and figured by Gruber (*Neue Anomal.* s. 28, Taf. I. fig. 1).

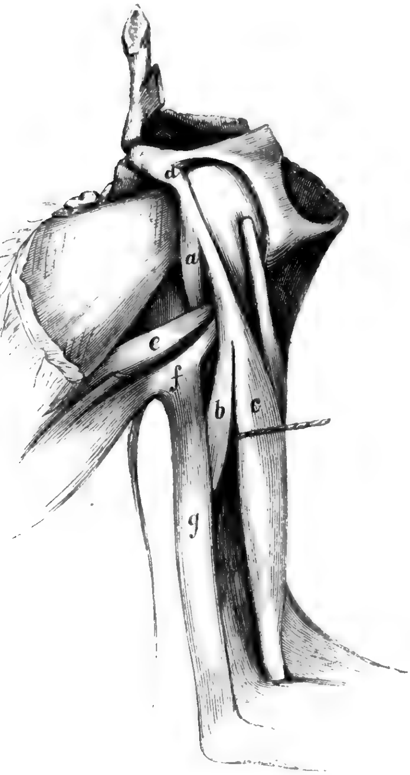
In many of such examples is found a tubercular projection, or a distinct spur-like process of bone, placed about two inches above the condyle, and a little in front of the condyloid ridge, which has been especially described by Otto (*De rarioribus scel. hum. c. anim. sceleto analogiis,* p. 25, Taf. I. figs. 10, 11), Knox (*Edin. Med. and Surg. Journal,* 1841, p. 125), and Struthers (*op. cit. Edin. Monthly Journal,*

Oct. 1848, and *Lancet*, Jan. 24, 1863), as homologous with the supra-condyloid arch in *Carnivora* and other animals. This process is described by the author last mentioned as either a rough line, a pointed tubercle, or a hook or spur, varying from $\frac{1}{10}$th to $\frac{3}{4}$ths of an inch in length. He had met with it in nine subjects, and had collected six more from Tiedemann, Quain, and other sources. I have myself seen it more or less distinctly developed in three cases. A case is also related by Wilbrand, quoted in the *British and Foreign Medical Review*, XIX. 571; and another by Barkow (*Anat. Abhandl.* s. 7, Taf. I. fig. 1), of the shape and size of the epitrochlear process. In all, the median nerve passed behind the process, and, in most, the brachial vessels also. In the subject from which the sketch (fig. 1) was taken, the supra-condyloid process was present as a tubercular projection into which the tendon of the lower or superficial portion of a large bifid *coraco-brachialis* muscle (*b*) was inserted. In the same arm were seen four heads to the biceps muscle, one (*e*) from the upper fibres of the *brachialis anticus*, and another (*f*) from those of the *supinator longus*, with an irregular distribution of the smaller arteries. An abnormal high origin of the *pronator teres* muscle is often present with the supra-condyloid process, as in the instances given by Tiedemann and Gruber (*op. cit.* s. 8).

Third. Much more rarely found as an abnormality in the human subject is another variation of the *coraco-brachialis* muscle. In a paper read before the Royal Society in 1864, I described and figured under the name of the *coraco-capsularis* a pretty strong bundle of muscular fibres arising from the under surface and outer border of the coracoid process near its root (fig. 2 *a*). Passing downward and slightly inwards across the tendon of the subscapularis muscle, the fibres dipped backwards below that tendon so as to become connected with the capsular ligament close to its insertion into the anatomical neck of the humerus, and was implanted upon the neck of the humerus close below the lesser tuberosity, between the *subscapularis* above, the long head of the *triceps* internally, and the *teres major* and *latissimus* (*c*) below. The latter tendons intervened between this insertion of the abnormal muscle and that of the normal *coraco-brachialis* (*b*), which was coex-

Fig. 2.

Fig. 3.



reaches by a few of its fleshy fibres the lower surface of the tip of the large and depressed coracoid (*d*), and is inserted, exactly as in the human variety, into the neck of the humerus above the tendons of the *teres major* and *latissimus* (*e* and *f*). The second or median portion (*b*) is inserted into the inner surface of humerus between the *triceps* and *brachialis anticus,* and is almost covered by the *biceps* (*c*) and *dorso-epitrochlear* (*g*) muscles. Such is its apparent dependence upon the biceps tendon for its origin, that it seems at first sight like a brachial insertion of that muscle.

In the other *Quadrumana* this double insertion of the *coraco-brachialis* almost universally exists. It was found by Duvernoy in the *gorilla,* by Vrolik in the *chimpanzee,* and by Church in the *orang.* Its bifurcation in *monkeys* is mentioned by Cuvier (*Leçons d'Anat. Comp.* Vol. I. p. 395), and by Kuhl in *Ateles belzebuth* (*Beiträge z. Beschreibung mehrer Mammalien,* s. 16); by Burdach in the *Simiadæ* (*Berichte von der Kön. Anat. Anstalt zu Konigsberg.* s. 25), by Burmeister in *Tarsius* (s. 49, T. iij. fig. 2. 14 and 14 *b*), by Mivart in *Cercopithecus sabæus* (*Proc. Zoolog. Soc.* Jan. 10, 1865), and by

Meckel (*Traité général d'Anat. Comp.* Vol. VI. p. 281) in the *lemurs.* This author states that in the *loris* the upper or smaller one only is present, but that in the *Lemuroidæ* generally the lower or long portion is so large as to reach to the inner condyle of the humerus. This would correspond to the third form of the muscle before described. He also states that in the *magot,* the *marmozet,* the *mandrill, callithrix,* and *ateles,* the upper portion is separated from the lower by the tendons of the *latissimus dorsi* and *teres major,* and that the musculo-cutaneous nerve passes between them (*op. cit.* p. 282). In *Nycticebus tardigradus,* and in one of the lemurs also, Mivart and Murie found a double coraco-brachialis inserted as in the animals just mentioned. (*Proceed. Zoolog. Soc.* Feb. 28, 1865.)

In the *hedgehog* I have found the *coraco-brachialis* single, and inserted into the middle of the humerus, arising by a single pointed tendon from the small coracoid. Meckel, however, states that it is double in this animal (p. 280), and that its lower insertion is tendinous and prolonged downwards. In the three-toed sloth (*Bradypus tridactylus*) it is slender and single, and inserted *below* the *teres* and *latissimus* into the middle of the humerus, having no connection with the *biceps.* In the *armadillo* it is also single, and is implanted upon the supra-condyloid arch or foramen just above the inner condyle, thus presenting the long variety of the muscle. In the *Ruminants* it is also single, and inserted, according to Meckel, as low down as the internal condyle. In the *horse, camel,* and *roebuck,* however, he states that it is divided into two parts, a superficial, longer and larger one inserted very low down, and a smaller and deeper muscle. On referring to Dr A. G. Leiserung's valuable *Atlas der Anatomie des Pferdes und der ubrigen Hausthiere,* I find that he figures there in the *horse* a complete and single *coraco-brachialis* with a low insertion; and also another small slip of muscle close upon the shoulder-joint capsule, arising from the scapula below the coracoid, and inserted into the neck of the humerus. This he calls the "*Spanner des Kapsel-bandes, oder kleiner Schulter-armbein Muskel*" (Taf. 5, fig. 1). Whether this represents the real *coraco-brachialis brevis,* or a slip of muscle sometimes found in the human subject detached from the lower fibres of the *subscapularis,* I am not prepared at present to decide. In the *Hyrax capensis,* according to Mivart and Murie, it reaches to the middle of the humerus. (*Proc. Zool. Soc.* April 11, 1865.)

In the *dog* and *cat* I have found the *short* variety the only representative of the *coraco-brachialis.* It arises singly from a diminutive coracoid close to the attachment of the *pectoralis minor* (*b*), by a pointed tendon (fig. 4 *a*), which, terminating in a flask-shaped muscle, is inserted fleshy into the neck of the humerus above the *latissimus*

Fig. 3.

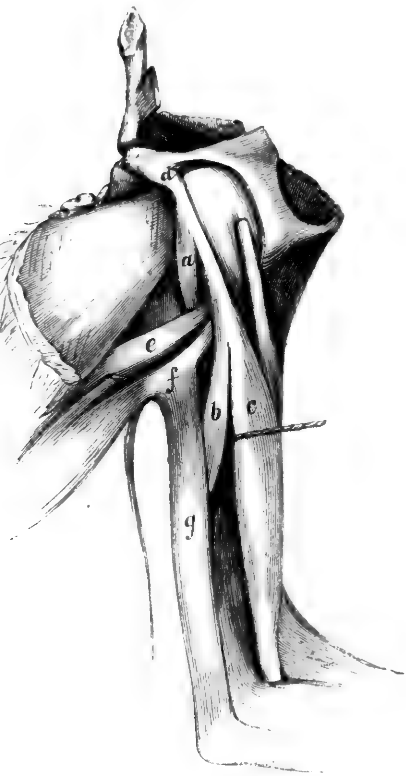


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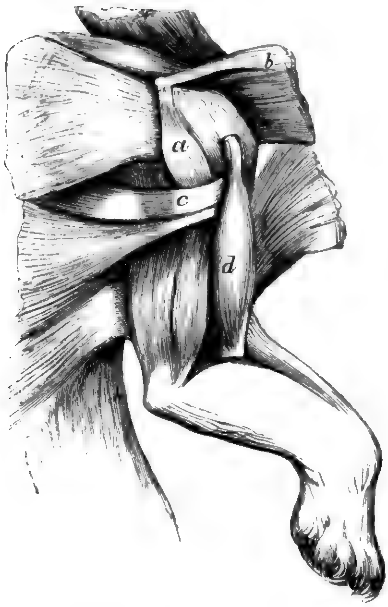
Fig. 4.



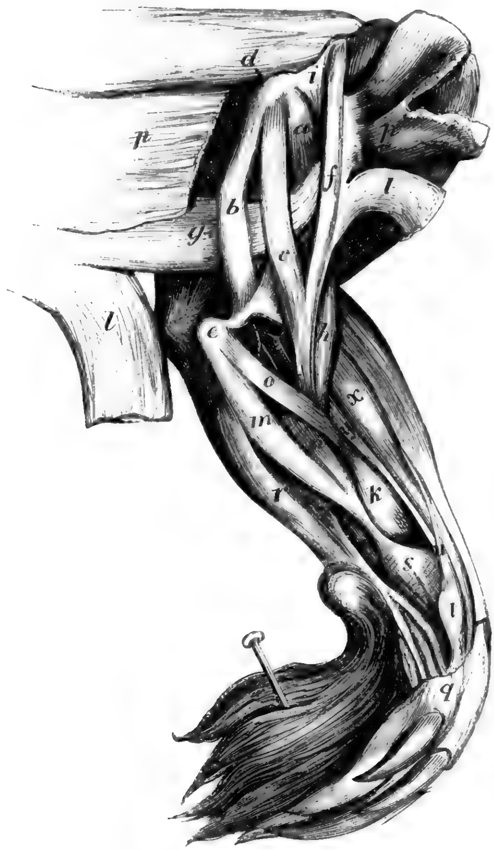
and *teres muscles* (*c*). In these, as in most of the lower mammalia, the *flexor* of the *radius* (*d*) has but one head from above the glenoid cavity, and cannot therefore be called a *biceps* muscle. Meckel states that the *coraco-brachialis* is single and very short in the *ichneumon, ratel, coati,* and *badger;* but that in the *marten* and *bears* it is double, the upper portion being inserted very high, and the lower reaching down as far as the epicondyle (*op. cit.* p. 281). This author also states that in the *otter* and *seal* he found *no* coraco-brachialis whatever. This is so singular an omission at this point of the animal scale, that it may be set down as requiring further confirmation, especially as it exists in the *Cetaceans* as a short muscle inserted close to the single brachial tuberosity. Professor Huxley found it present, though small, in the *porpoise* (*Lect. at Roy. Coll. of Surgeons*). In the *Bats* and *Moles* the short variety only represents the *coraco-brachialis.* In the *Rodents* a great variety of insertion is exhibited by this muscle. In the *guinea-pig* (*cavia aperæa*) and *rabbit* I have found it single, and inserted just below the *latissimus* and *teres*, and therefore belonging to the first or median variety. Meckel states that in the *hare* and *capybara* he has found it very short; double in the *marmot, beaver,* and *hamster,* one part inserted very high, and the other into the lower half of the humerus; and very long and strong, though single, in the *porcupine* and *squirrel,* extending, I have found, in the latter animal, as far down as the lower end of the humerus. This absence of uniformity in the *coraco-brachialis* does not coincide with

the presence or absence of the clavicle, or of the supra-condyloid foramen in these animals, but it does seem to refer to their habits, being double or longer and stronger in those which employ their fore paws for prehension.

In the *kangaroo* the *coraco-brachialis* is said by Meckel to be entirely wanting. This is the more striking, since it is present as a short variety, very small, and inserted above the *teres* and *latissimus* in the *kangaroo rat*, a closely related *Marsupial;* and in the next order of *Monotremata* we find it in its highest development. In the *Echidna hystrix* it possesses a larger proportionate bulk than in any I have yet seen. From the large coracoid bone arises a mass of muscle which at first sight might be taken for a part of the *triceps.* On further examination, however, it is found that a considerable portion of its superficial layer forms the only origin of the *flexor radii* (biceps), while the rest is inserted into the whole length of the inner side of the humerus from the tendons of the *latissimus* and *teres* down to the enormously prominent condyle. Under the lower part of its insertion is seen the small supra-condyloid foramen, as if bored through the substance of the humerus, and transmitting the brachial vessels and median nerve. Above this, the upper can be easily separated from the lower fibres in an areolar interval. The deepest portion of the muscular mass springing from the coracoid is separated from the rest by a distinct fascial interval, and forms a somewhat oval, wide, short muscle, which is implanted into the lower part of the transversely prominent inner or ulnar tuberosity of the humerus. My own dissections in this respect corroborate the observations of Mr H. G. Mivart, "On the Anatomy of the *Echidna*" (*Trans. Linn. Soc.* Vol. XXV.).

In the *Ornithorhynchus paradoxus* (fig. 5) the lower or long portion of the *coraco-brachialis* (*b*) is much smaller than in the *echidna*, the upper part of its fibres appearing to be given off to form the coracoid head of a double-headed *flexor radii,* or true *biceps* (*c*). The rest of the fibres are implanted below the brachial vessels and nerves upon the supra-condyloid arch or foramen, close above the epitrochlea (*e*), and represent the second part of the muscle as before described. The first or middle part is here wanting or incorporated with the biceps muscle. In both the *echidna* and *ornithorhynchus* the short muscle, or *rotator humeri,* called by Meckel (*De Ornithorhyncho*) the *coraco-brachialis superior,* is a very distinct and bulky muscle, of a somewhat fan-shape, springing from the broad coracoid (*d*), deeper than the biceps and longer portion, and implanted by a broad insertion into the lower border of the widely expanded inner or ulnar tuberosity of the humerus, above the insertions of the latissimus dorsi and teres major (*g*).

Fig. 5.



The outer or long head of the *biceps* arises fleshy from a tubercular projection placed above the capsule of the scapulo-humeral joint (*i*), which is placed between and behind it and the coracoid muscles. In the figure the *pectorals* (*p*) and the outer insertion of the *latissimus* (*l*) are cut and turned back. The action of the *rotator humeri* in these animals upon the humerus is very evident, its power of adduction being, however, limited from the close propinquity of the tuberosity of the humerus to the coracoid. The swimming and burrowing habits of these animals evidently call for much rotatory play of the arm-bones, the provision for which is found in the lower segment of the limb by the enormous size of the *supinator brevis,* especially in the *echidna,* in which animal it reaches along the whole length of the radius.

That the kind of *coraco-brachialis* muscle with which an animal is provided is not determined by its order, is seen clearly in the *Rodents,* since in them we have the short variety only in the *hare* and

capybara, the long variety only in the *squirrel* and *porcupine,* the median variety only in the *guinea-pig,* and two combined in the *marmot, beaver,* and *hamster.* Again, in the *Carnivora* we have the short variety only, as in the *dog, cat, ichneumon, coati,* and *badger;* and two varieties combined, as in the *martens* and *bears.*

It is somewhat remarkable also that in the *Rodentia* we have a like want of resemblance in the presence or absence of a clavicle, or an imperfect clavicle; of a supra-condyloid foramen, and of an inter-condyloid foramen, the two latter seeming to bear something of an opposing character, one being usually absent, while the other is present. The *rotator humeri* is found both in the claviculate *Quadrumana, Insectivora, Rodentia,* and *Monotremata,* and in the non-claviculate *Rodents* and *Carnivora;* while the *long coraco-brachialis* seems to be present in animals without as well as with a supra-condyloid foramen, and the double form almost equally indiscriminately found.

This very variable arrangement seems to point upon the whole much more directly to a "teleological" than to a "morphological" reason for existence, and to refer much rather to the wants and habits of the animal than to its pedigree or relationship. Those which use the fore-limbs for distinct prehension, digging, swimming, or climbing, have, as a rule, a larger and more highly developed *coraco-brachial* muscular apparatus.

Flexor carpi radialis brevis vel *profundus.*—In six out of about seventy subjects in the dissecting I have found an abnormal muscle on the flexor side of the fore-arm, connected with the carpus near the insertion of the *flexor carpi radialis.*

In that which I have considered as the best developed specimen, the supernumerary muscle arose from the outer side of the front surface of the radius above the *pronator quadratus,* and a little to the outside of and below the *flexor longus pollicis.* The fleshy belly of the muscle resembled in shape, and was nearly as large as that of the *flexor longus pollicis,* tapering much in the same penniform way. (See fig. 6 *a*). It terminated just above the carpus in a distinct rounded tendon, which, lying under the annular ligament upon the deep process which secludes the groove of the *flex. carpi radialis* and between it and the tendon of the *flex. pollicis,* finally spread out, and becoming flattened, was inserted into the base of the middle metacarpal bone (*c*) and os magnum, where it was connected with a slip of the tendon of the *flex. carpi radialis,* and gave origin to some of the fibres of the *flex. brevis pollicis.*

In two of the cases the muscle terminated in a somewhat smaller but equally distinct tendon, which passed with that of the *flexor carpi radialis* through the sheath in the annular ligament, was lodged

in the trapezoid groove, and became implanted on the inside of, but quite distinct from, the last-named tendon, into the ulnar side of the base of the *second* metacarpal bone. Even in this shape the muscle could not be considered as a division of the tendon, and still less of the muscular fibres of the *flexor carpi radialis,* inasmuch as its origin was so totally distinct, referring rather to the *flexor pollicis longus* in this particular.

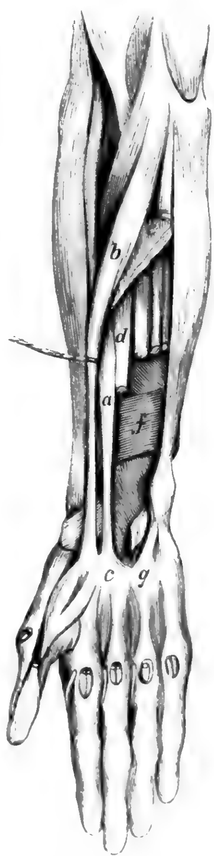
In another instance the muscle arose by a lunated aponeurosis as high as the oblique line of the radius, beneath the fibres of the radial origin of the *flexor sublimis digitorum.* The muscular belly was fusiform, beginning by a thick tendon from the lunated aponeurosis, and tapering downward rapidly into a thick flattened tendon, which was inserted into that deep process of the annular ligament which encloses the groove for the *flexor carpi radialis,* and is attached to the trapezoid, magnum, and middle metacarpal.

In another subject the fusiform muscle, having a similar origin, and lying at first on the outer side of the *flexor longus pollicis,* crossed in front of its tendon obliquely opposite the carpus, and became implanted into the deep surface of the annular ligament itself, sending numerous fibres into the deep surface of the middle portion of the palmar fascia. In the last form the abnormal muscle first presented itself to me, and I was led to consider it in the light of an abnormal palmaris, in consequence of its attachments to the deep surface of the palmar fascia. A properly formed *palmaris longus* was, however, coexistent in this case. Under the head *palmaris* Theile describes an abnormality in every respect like the last-mentioned, and lying, like it, *under* the flexor sublimis with the median nerve. In his case, however, the *palmaris longus* was absent (*op. cit.* p. 237). I had before met with a double *palmaris longus* of which the abnormal head was derived from the oblique line of the radius, but in origin and position quite *superficial* to the radial origin of the *sublimis. Rosenmüller* and *Henle* (*op. cit.*) have met with a variety somewhat similar; but in both cases the normal origin of the *palmaris* was entirely absent, and its place supplied by a tendon from the radial origin of the *sublimis.*

The subsequent discovery of other forms of this abnormal muscle forming a gradual serial transition to the complete form first described, and resulting in a distinct flexor attached to the base of the third metacarpal bone; together with the deep origin beneath the flexor sublimis of all these varieties, and the invariable presence of a normal *palmaris longus,* have induced me to form the conclusion that all these varieties belong to one type, which, in its complete development, is a *proper flexor of the third metacarpal bone.* The name of *Flexor carpi radialis brevis seu profundus* has appeared to

me most completely to include all the above-mentioned varieties:—viz. both those attached to the third metacarpal and magnum; those inserted into the second metacarpal and trapezium; and those inserted into the trapezium annular ligament and palmar fascia;—all arising from the radius, either below its middle, or from the oblique line below and beneath the radial origin of the *flexor sublimis.* In a muscular male arm which I dissected last session, now in the Museum of the Royal College of Surgeons, and from which the accompanying sketch (fig. 6) was taken, the special function of a proper flexor of the third metacarpal bone is clearly indicated by a distinct and separate insertion into the base of that bone. In the sketch the *flexor carpi radialis* (*b*) is drawn aside, shewing under it the *flexor carpi radialis brevis* (*a*), or special flexor of the middle metacarpal bone (seen at *c*), and arising from the radius beneath the radial origin of the *flexor sublimis* (*e*) outside the *flexor longus pollicis* (cut at *d*), and above the *pronator quadratus* (*f*). A few of the deep fibres of the *flexor brevis pollicis* are seen arising from the insertions of both the radial flexors. In the same arm was found a slip, given off from the tendon of the *flexor carpi ulnaris* to the base of the fourth metacarpal (*g*), as well as the usual slip to that of the fifth and annular ligament, beyond the pisiform bone. We have here then the remarkable development of a special flexor for each of the metacarpal bones (including the *opponens pollicis*). These are the more interesting in being associated in the same arm with a *special extensor* of the middle finger, and a double *extensor minimi digiti* with one of the tendons passing to the *ring finger,* thus forming a complete set of special extensors in addition to the common extensor tendons. In the leg of the same subject was a *peroneus quinti,* i.e. a tendinous slip from the *peroneus brevis* to the little toe, and an *abductor* of the fifth *metatarsal bone,* both ape-like peculiarities.

Fig. 6



A special flexor of the middle metacarpal bone, corresponding in all essential particulars with that just described, has been found also by Mr Norton, in a subject dissected at St Mary's Hospital during the past year.

Albinus records a case in which the tendon of the *flexor carpi*

radialis gave off a slip to the trapezium, and to the base of the third and fourth metacarpal bones, and *Fleischmann*, a case in which that muscle reached only to the annular ligament and the scaphoid and trapezium; quoted by Henle (*Muskellehre*, s. 191).

But I have not been able to find any mention of a distinct muscle like that under consideration in any anatomical author, English, French or German, that I have been able to consult. I have been equally unsuccessful in finding a similar muscle described by writers on the muscular anatomy of the lower animals. Nor have I found any muscle resembling it in any of the animals in which I have looked for it, except in the *Monotremata*, at a distance in the animal scale from which it is so far to fetch an homology of this kind, that I have hesitation in laying stress upon it. In the fore-limb of both the *Echidna hystrix* and the *Ornithorhynchus paradoxus*, from which latter fig. 5 was taken after dissection, I have found a second or deep head of the *flexor carpi radialis* (*n*), which seems to correspond to some extent with this abnormal human muscle. This deep head occupies entirely the position in front of the radius and interosseous ligament which is usually filled by the *flexor longus pollicis*, the latter muscle being in these animals entirely merged in the *common flexor of the digits* (*r*), which sends off from its palmar ossicle the tendon to the pollex (*q*). The deep head of the *flexor carpi radialis* is connected at its lower part by an intermuscular septum to the usual superficial portion of the muscle (*m*), and joins its tendon just above the carpal end of the radius. From thence it stretches upward, close to the radius and interosseous ligament (with which it is connected by aponeurotic fibres), and passing under the *pronator radii teres* (*o*), is placed in front of the elbow-joint, and connected with the lower end of the humerus, between it and the *supra-condyloid foramen*, through which may be seen in the sketch the median nerve and brachial vessels emerging upon the upper part of the muscle under consideration. The *brachialis anticus* (*h*) is placed externally, and is inserted in these animals entirely into the radius. The combined tendon of the superficial and deep portions of the double-headed *flexor carpi radialis* is inserted ultimately by an aponeurotic expansion into the bases of the metacarpals of the pollex (*t*), index, and middle digit, and into the trapezium. A supernumerary ossicle, however, intervenes between the tendon and its aponeurotic insertion over the site of the scaphoid-lunar bone. In the *ornithorhynchus* this ossicle is fairly imbedded in the tendon; but in the *echidna* the latter can be easily dissected from it, revealing the presence of a distinct bursal sac between it and the trapezium. In the *ornithorhynchus* also more of the deeper fibres are implanted upon the trapezium itself than in the *echidna*.

In the former animal the *pronator quadratus* (k) is much more developed than in the latter. One of the *radial extensors* (v) is connected at its insertion into the carpal bones with the expansion of the tendon of the flexor going to the pollex. The last-mentioned muscle is described by Meckel (*De Ornithorhyncho*) as a *supinator longus.* I think, however, that its want of attachment to the radius, its want of supinating power, its deep position, and its relation to the fellow muscle (x) of the same name, indicate its identity as one of the radial extensors of the carpus. The other radial extensor (x) is six or eight times larger, and its tendon is inserted into the bases of the second, third, and fourth metacarpals, so that it represents by its insertion (as is commonly found in the lower animals) *both* the radial extensors of the human subject. If this be so, in what light must we look upon the smaller muscle described by Meckel as a supinator longus? I am inclined to look upon it as the representative of a muscle which I have found occasionally in the human subject, and which I have described and figured in the paper before mentioned, in the *Proceedings of the Royal Society* of the present year, as the *extensor carpi radialis accessorius.* This muscle arises, with the ordinary *radial extensors,* from the external condyloid ridge, and is inserted into the base of the metacarpal of the pollex *with the extensor ossis metacarpi pollicis.* In the *ornithorhynchus* the tendon of the small deep muscle (v), though apparently lost on the dorsal surface of the scapho-lunar bone, is yet connected with a fascial expansion, which is carried onward to the base of the first metacarpal beneath the tendon of the *ext. ossis metacarpi pollicis* (u). In the *echidna* the corresponding muscle is considered by Mivart (*op. cit.*) to represent the *extensor carpi radialis longior*, and the much larger, and more superficial one, the *brevior.* In that animal, however, the tendon of the former (as in the *ornithorhynchus*) reaches no further than the scapho-lunar bone, while that of the *brevior* is inserted into the second, third, and fourth metacarpals. The deeper position and lower origin from the condyloid ridge of the humerus of the muscle in question, would seem opposed equally to this way of viewing it as to that of Meckel.

ON TWO WIDELY CONTRASTED FORMS OF THE HUMAN CRANIUM, by THOMAS H. HUXLEY, F.R.S.

THE two most thoroughly contrasted human skulls, taking them altogether, which have hitherto fallen under my notice, are those various aspects and sections of which, reduced to one-third of the size of nature, are represented in the accompanying woodcuts.

The one of these skulls, which I shall call *A*, belongs to the Museum of the Royal College of Surgeons of England, and is thus described in the 'Osteological Catalogue:'

"5484. The cranium of a native of Tartary.

"It is remarkable for its breadth and shortness, slightly convex superior surface, and broad, high, and vertical occipital surface. The forehead is broad but low. The nasal bones are large and prominent; the malars are not prominent. The anterior alveoli of the upper jaw slope forwards.—*Hunterian.*"

For the opportunity of examining and making the requisite section of the other skull, *B*, I am indebted to J. B. Sedgwick, Esq., into whose possession it came, many years ago, as a 'New Zealand' skull.

Among a good many New Zealand skulls which I have examined, however, none resemble this; while it presents so many Australian characters, that I am disposed to think it must have been obtained either in Australia, or in one of the Negrito islands. For it is a circumstance worthy of much attention, that the crania of the more or less woolly-haired Negrito inhabitants of Tasmania, New Caledonia, the Feejees, the New Hebrides, &c. present strongly Australian features, and are frequently altogether indistinguishable, by their external characters, from those of the leiotrichous Australians.

However, the precise origin of these skulls is not a matter of any moment in relation to my present purpose, which is simply to indicate the nature, the extent, and the relations of the more important anatomical differences between the two skulls; and, incidentally, to illustrate the mode of comparing skulls which seems to me best calculated to render their real differences apparent.

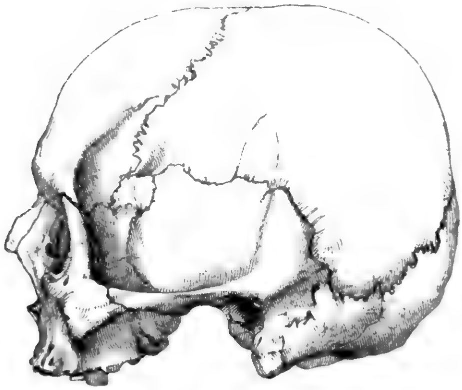


Fig. 1. The skull *A*. *Norma lateralis.*

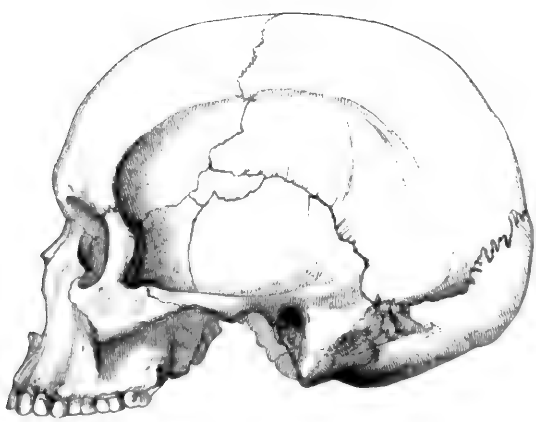


Fig. 2. The skull *B*. *Norma lateralis.*

Fig. 3. The skull *A*. *Norma facialis*.

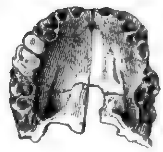


Fig. 3*a*. The palate of the skull *A*.

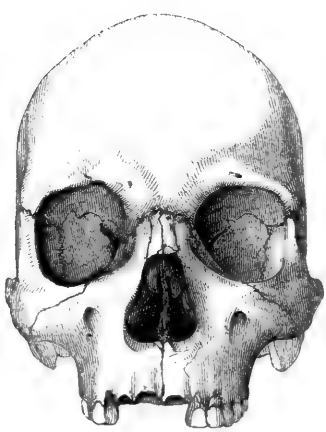


Fig. 4. The skull *B*. *Norma facialis*.

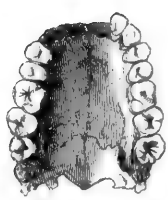


Fig. 4*a*. The palate of the skull *B*.

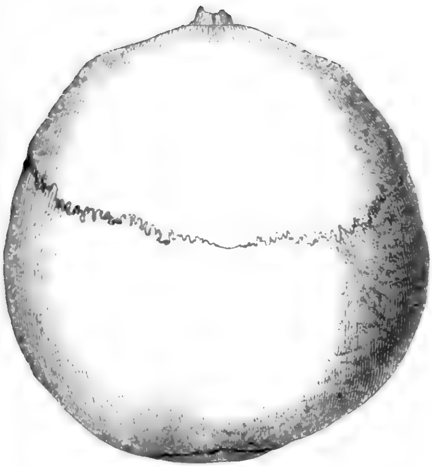


Fig. 5. The skull *A*. *Norma verticalis*.

Fig. 6. The skull *B*. *Norma verticalis*.

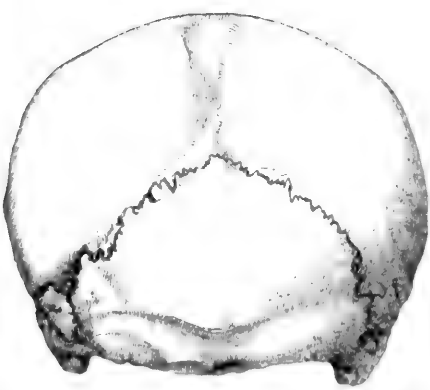


Fig. 7. The skull *A*. *Norma occipitalis*.

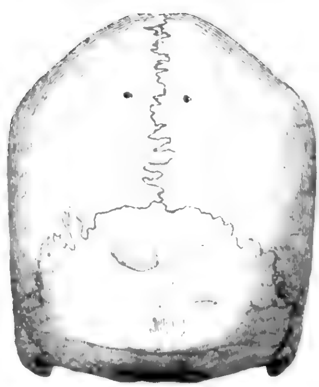


Fig. 8. The skull *B*. *Norma occipitalis*.

The skull *A* is the broadest undistorted cranium which has come under my notice, its index being ·977. It is, therefore, eminently *brachistocephalic*[1]. When held out, at arm's length, so as to present the *norma verticalis* to the eye (fig. 5), its bulging sides completely hide the zygomatic arches. It is, therefore, in Mr Busk's nomenclature, *cryptozygous.*

The *squama occipitis* has a well marked convexity, separated in the middle line by a depression (fig. 1) from the parietal region. A slighter depression occurs on the middle of the coronal suture; but, neither in this region, nor elsewhere, can I discover any indications of artificial distortion, unless a certain amount of asymmetry of the occiput (fig. 5), produced by the flattening of the right side (probably from nursing) can be regarded as such. The coronal suture is open, throughout its whole extent, on both the inner and the outer faces of the skull; as are the lambdoidal, occipito-mastoid, alisphenoidal, squamosal, nasal, and fronto-nasal sutures. But the sagittal suture is so absolutely obliterated, that not a trace of it is discernible on either the outer, or the inner, surfaces of the skull (figs. 5 and 7).

The squamosal and the frontal are separated on both sides, partly by the parietal and partly by an intercalary bone, which is small on the right side, larger on the left, and lies between the parietal and the alisphenoid (fig. 1).

The auditory foramina are rounder than usual; the mastoid processes are well developed and prominent; the upper edge of the zygoma is nearly straight. The face is orthognathous, on the whole, though there is a certain amount of alveolar prognathism.

Turning to the base of the skull, the obliquity of the axes of the glenoid cavities is very remarkable. If these axes were prolonged inwards, they would cut one another as far back as the junction of the middle and anterior thirds of the occipital foramen. The axis of this foramen is directed downwards and forwards.

Traces of the maxillo-premaxillary suture are visible upon each side of the naso-palatine foramen. The palato-maxillary suture is unclosed, and convex forwards in the middle line (fig. 3*a*).

[1]

Cephalic index	....	at or above	·80 = BRACHYCEPHALI, round skulls.	
......		......	·85 = *Brachistocephali*.	
......	below ·85 and	......	·80 = *Eurycephali*.	
......	... ·80		= DOLICHOCEPHALI.	
......	... ·80	......	·77 = *Sub-brachycephali*	oval skulls.
......	... ·77	......	·74 = *Orthocephali*	
......	... ·74	......	·71 = *Mecocephali*	
......	... ·71		= *Mecistocephali*, oblong skulls.	

See "Notes upon the Human Remains from Keiss," in Mr Laing's *Prehistoric Remains of Caithness*, p. 85.

The frontal sinuses are extensive, and are separated by an imperforate septum, which lies a little to the right of the middle line. The body of the sphenoid and the roots of its lesser and greater alæ are occupied by the sphenoidal air-cells, the right cell extending back, beneath the sella turcica, to the posterior limit of the body of the basi-sphenoid.

The right second bicuspid and first true molar are the only teeth which remain, and their crowns are ground down to flat surfaces by wear. From this and other circumstances there can be no doubt that the possessor of this skull had attained middle age.

While *A* is the widest, *B* is the narrowest normal skull I have met with, its index being only ·629. It is, therefore, an extremely marked example of *mecistocephaly*. It is, further, *phænozygous*, the *norma verticalis* exhibiting a space between the zygomatic arches and the sides of the brain-case (fig. 6).

The sagittal, coronal, lambdoidal, occipito-mastoid, alisphenoidal, squamosal, nasal, and fronto-nasal sutures, are open throughout their whole extent.

The frontal and the squamosal bones remain separate on both sides. On the left side, there is a considerable intercalary bone between the alisphenoid, parietal, frontal, and squamosal (fig. 2).

The auditory foramina are vertically elongated, perhaps more so than is usual: and they are, both absolutely and relatively, narrower than those of *A*. The mastoid processes are well developed and prominent. The upper edge of the zygoma is slightly convex upwards.

The face is obviously prognathous.

On the base of the cranium the axes of the glenoid cavities, if prolonged inwards, would cut one another about half an inch in front of the anterior edge of the occipital foramen, so that they are nearly transverse to the long axis of the skull. The axis of the occipital foramen is directed downwards and forwards. Faint indications of the maxillo-premaxillary suture are discernible upon both sides. The maxillo-palatine suture persists, and is arched forwards in the middle line (fig. 4*a*). The frontal sinuses are divided by a septum, which is inclined to the left side above. They are not quite so large as in *A*, but they are much larger than is usual in true Australian skulls.

The large sphenoidal air-cells are divided in the middle line by a septum. They do not extend back further than the middle of the pituitary fossa. The last molar is cut and in use; but the other teeth are only slightly worn. The skull may have belonged to a person of between twenty-five and thirty years of age.

In the *norma lateralis* (figs. 1 and 2), beside the points already mentioned, the great difference in the longitudinal contours of the two skulls is obvious. Further, the temporal ridge, sharply marked in *B*, is almost obsolete in *A*. The supra-auditory ridge, on the other hand, is more distinct in *A* than in *B*. The occipital spine is not very strong in either skull; and in both, the contour of the *squama occipitis* projects beyond it when the skull is horizontal. This projection is greater in *B*. In the *norma occipitalis* (figs. 7 and 8) there is a wonderful contrast between the spheroidal dome of *A* and the sharply ridged, wall-sided, pentagon of *B*; an opposition quite as marked in its way as that between the *normæ verticales* (figs. 5 and 6) of the two crania. The denticulations of the sutures are, for the most part, more simple in *B* than in *A*.

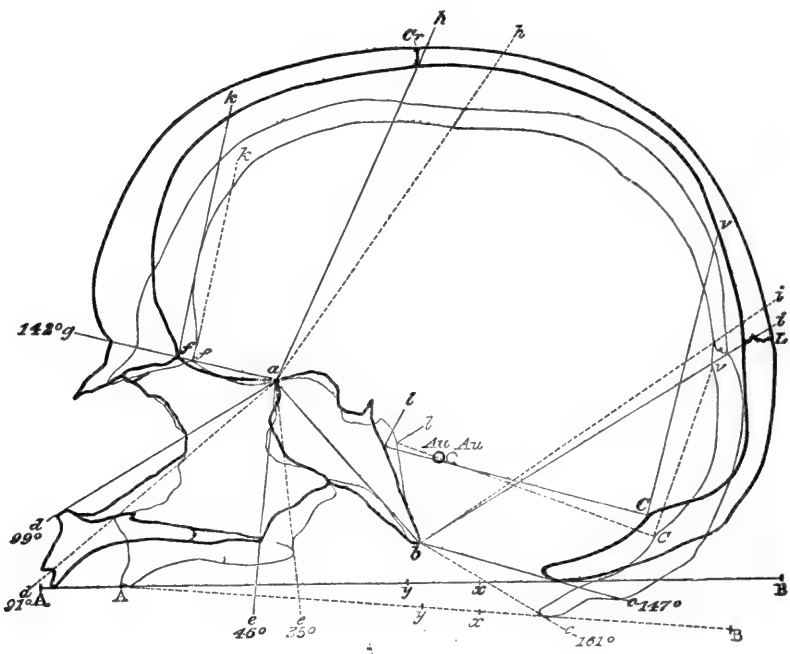


Fig. 9. **Diagram exhibiting longitudinal and vertical sections of the skulls *A*, *B*, reduced to one-half the size of nature and superimposed. The thick contour lines and letters belong to *B*, the thin ones and the dotted lines to *A*.**

Each of the skulls *A* and *B* has been longitudinally and vertically bisected, and the outlines of each section having been accurately marked upon sheets of tracing paper, the one outline has been superimposed upon the other, in such a manner, that the *basicranial*

axes[1] correspond in direction, while their anterior ends, situated at the point of junction of the presphenoid and ethmoid, coincide.

The resulting figure, reduced to one-half the size of nature, is given in fig. 9. In this figure *a, b* represents the basicranial axis; *bc, bc* lines drawn from the occipital end of the basicranial axis to the opposite boundary of the occipital foramen. The angle *a, b, c,* therefore, indicates the inclination of the plane of the occipital foramen to the basicranial axis, and will be small, or great, in proportion to the extent to which the occipital foramen looks forwards and downwards. It is analogous to, though not identical with, Daubenton's angle. *ad, ad* are lines drawn from the ethmoidal end of the basicranial axis to the anterior edge of the premaxilla, where it bounds the nasal aperture. The angle *b, a, d* may be termed the *premaxillary angle.*

ae, ae mark lines drawn from the ethmoidal end of the basicranial axis to the middle of the posterior margins of the palatine plates of the palatine bones. The angle *b, a, e* may be termed the *post-palatine angle.*

The line *ag* is drawn from the anterior end of the basicranial axis, through the upper ends of the ethmo-frontal sutures, *f, f*; *af, af* consequently indicate the lengths of the respective cribriform plates; while *ag* defines the general planes of those plates; which happen, in the present case, to coincide.

b, a, g is the *basi-ethmoidal angle,* which diminishes in proportion as the line *ag* rotates downwards upon *a*; or, in other words, in proportion to the departure of the human skull from the condition of that of the lower *Mammalia.*

fk, fk are perpendiculars to the line *ag* erected upon the point *f.* The distance between these lines and the inner contour of the frontal bones is a measure of the *anterior cerebral overlap;* or, of the extent to which the frontal lobes of the brain project beyond the extremities of the olfactory nerves. *ah, ah*; *ai, ai,* are lines drawn from the anterior end of the basicranial axis to the middle of the coronal and lambdoidal sutures *Cr, L.*

lC, lC are lines drawn from *l, l,* the points at which the inner end of the posterior superior margin of the petrosal cuts the basicranial axis, to the *torcular Herophili.* Each may be taken to represent the *tentorial plane,* though, of course, the centre of the tentorium would rise considerably above it. *Cv* is a perpendicular erected upon the hinder end of this line and marking the projection of the cerebral

[1] By *basicranial axis*, I mean, a line drawn through the middle vertical plane of the *basioccipital*, *basisphenoid* and *presphenoid*, from the hinder extremity of the former bone to the anterior extremity of the last, at the upper end of the ethmo-presphenoid suture.

hemispheres beyond the cerebellum, or the *posterior cerebral overlap.* AB is a line representing the extreme length of the entire cranium; y, its centre; x, the point cut by a perpendicular from the centre of the occipital foramen. Au the internal auditory foramen, L the lambdoidal, Cr the coronal suture.

The various measurements of the two skulls, to which I shall have to advert, may be conveniently classified under three heads; 1stly, those which are identical; 2ndly, those which differ by not more than five per cent.; 3rdly, those which differ more than five per cent.

They are given in $\frac{1}{100}$ths of an inch, not from any desire to affect an accuracy to which cranial measurements can lay no claim, but for the sake of more ready comparison. It must be understood that very few cranial measurements will come out exactly alike twice over; so that the numbers given must, in most cases, be regarded simply as a mean; the variations from which will not affect the general result.

I. *Identical measurements (in $\frac{1}{100}$ths of an inch).*

		A.	*B.*
1.	The basicranial axis	235	235
2.	The vertical height of the face from the fronto-nasal suture to the alveolar margin	260	260
3.	The vertical height of the orbital aperture	135	135
4.	Anterior interlachrymal diameter, from the point of junction of the frontal, lachrymal and maxillary, on the one side, to that on the other	75	75
5.	From the margin of the orbit to the alveolar margin between m^1 and m^2	175	175
6.	The greatest breadth of the palate taken between the inner edges of the alveoli	140	140
7.	The greatest length of the palatine plate of the palate-bone	75	75

II. *Measurements which do not differ more than 5%.*

Differences in favour of B are marked with a *.

		A.	*B.*	Diff.
8.	The longitudinal arc of the frontal	512	537	*25
9.	The longitudinal arc of the occipital	430	426	4
10.	The greatest transverse diameter of the occipital bone from one occipito-mastoid suture to the other	443	422	21
11.	The length of the occipital foramen	145	140	5
12.	The distance of the suborbital foramina ...	230	220	10

		A.	*B.*	Diff.
13.	The length of the zygoma from the anterior edge of the auditory foramen to the anterior end of the maxillo-jugal suture	310	323	*13

III. *Measurements which differ more than 5%.*

14.	Extreme length	670	755	*85
15.	Extreme breadth	655[1]	475[2]	180
16.	Height	480	530	*50
17.	Longitudinal arc of the parietals	450	550	*100
18.	Transverse arc from one auditory foramen to the other	1350	1175	175
19.	Width of the frontals immediately behind the external orbital process (least frontal measurement)	405	340	65
20.	Width of the frontals on the temporal ridge just above the external orbital process ...	417	375	42
21.	The greatest frontal width, where the temporal ridge cuts the coronal suture	555	395	160
22.	Length of the cribriform plate	95	107	*12
23.	Posterior interlachrymal diameter, between the junctions of the ethmoid, lachrymal and frontal	105	90	15
24.	Between the posterior ends of the ethmo-maxillary sutures	170	155	15
25.	Between the outer edges of the optic foramina in the interior of the skull	126	85	41
26.	Between the outer edges of the optic foramina in the orbits	155	115	40
27.	Between the outer sides and posterior edges of the bases of the external pterygoid processes	205	176	29
28.	Between the points of the alispheno-squamosal sutures, which are cut by the transverse ridge on the alisphenoid	360	320	40
29.	Between the outer edges of the foramina ovalia	240	193	47
30.	Between the posterior ends of the alispheno-squamosal sutures and outer sides of spinous processes	305	245	60
31.	Between the outer edges of the glenoidal fossæ	533	455	78
32.	Between the most distant points of the outer surfaces of the mastoid processes ...	536	452	84

[1] Between the upper edges of the squamosals, over the auditory foramina.

[2] Between the parietal tuberosities.

		A.	B.	Diff.
33.	Transverse arc of the occipital, from the junction of the lambdoidal suture and its additamentum on one side, horizontally over the occiput to the other side	500	636	*136
34.	Between the centres of the styloid foramina...	360	290	70
35.	Least breadth of the basicranial axis (between the apices of the *partes petrosæ*)	100	75	25
36.	Between the inner edges of the precondyloid foramina	150	125	25
37.	Between the most distant points of the outer edges of the occipital condyles	215	185	30
38.	Transverse diameter of the occipital foramen .	125	105	20
39.	Between the internal auditory meatuses ...	245	155	90
40.	Length of the posterior superior edges of the ossa petrosa	270	245	25
41.	Extreme transverse distance of the outer surfaces of the zygomata	555	485	70
42.	From the lower end of the basicranial axis to the anterior alveolar margin of the premaxilla	332	420	*88
43.	From the lower end of the basicranial axis to the posterior end of the spine of the palate	137	165	*28
44.	Extreme distance of the outer surfaces of the maxillæ	220	242	*22
45.	Width of the external nasal aperture ...	92	105	*13
46.	Greatest perpendicular height of the nasal passage, from the cribriform plate to the upper surface of the palate	177	160	17
47.	Extreme distance of the outer walls of the posterior nares	115	98	17
48.	Height of the arch of the posterior nares ...	100	92	8
49.	From the posterior end of the spine of the palate to the anterior margin of the premaxillæ	195	253	*58
50.	Length of a line drawn from the anterior edge of the premaxilla along the posterior edge of the occipital foramen, and cut by a perpendicular tangent to the occiput, *A*, *B*, fig. 9.	660	810	*150
51.	Length of so much of this line as lies in front of a point cut by a perpendicular to the centre of the occipital foramen (*A*, *x*) ...	390	480	*90
52.	Length of the line behind this point (*x*, *B*) ...	270	330	*60

	A.	B.	Diff.
53. Projection of the inner contour of the frontal beyond the level of a perpendicular to the anterior end of the cribriform plate (=anterior cerebral overlap)	20	55	*35
54. Projection of the inner contour of the occipital beyond the *torcular Herophili* (= posterior cerebral overlap)	30	85	*55
55. The capacity of the cranium and volume of the brain, as determined by the volume of a cast of the interior of the skull, in cubic inches	95	80	15
56. Extreme length of the cast	625	695	*70
57. Extreme breadth	615	455	160
58. Breadth : length = 100	98	65	

1. The first point to be noted in comparing the skulls *A* and *B*, the most important measurements of which have now been given, is the equality of length of their *basicranial axes,* which proves that brachycephaly and dolichocephaly are not necessarily connected with the shortening or the lengthening of the base of the skull; but that their most extreme forms may arise exclusively from modification of the side walls and roof of the cranium. In the present case, the difference in the absolute lengths of the two skulls amounts to about 11% of the length of the longer (*B*). It is due, in part, to the remarkable shortness of the parietal region in *A*, the longitudinal arc of the parietals being about 18% (No. 17), and its chord 20%, longer in *B* than in *A*. In part, the superior length of *B* arises from the forward extension of the frontal region, which will be more particularly discussed below. The elongation of the occipital region does not seem to be greater than that which would necessarily accompany the lengthening of the parietals.

The difference in breadth between *A* and *B* (No. 15) amounts to 27% of the broader. It is greater absolutely and relatively than the sum of the excess of height and length of *B* over *A*.

2. Virchow's "sattel-winkel" is substantially the same in the two skulls, though the one is vastly more prognathous than the other. Hence it follows that there is no necessary connexion between the "sattel-winkel" and prognathism or orthognathism.

3. It will be observed, that only one pair of the transverse measurements, which differ less than 5%, appertain to the brain-case. These are No. 10, the greatest transverse diameters of the occipital bone. In all the other transverse measurements of the brain-case (with the exception of No. 33, the transverse arc of the occipital, which is in reality as much a longitudinal as a transverse dimension)

A exceeds *B*. Hence it appears that, in such a thorough example of brachycephaly as this, the excess of transverse growth is general, and affects all parts of the brain-case. But the excess is not equal in all regions of the skull.

Thus in No.	35 the excess of *A* is about	25%
....	39	36%
....	36	16%
....	34	19%
....	32	15%
....	31	14%
....	30	20%
....	29	19%
....	28	11%
....	27	14%
....	25	33%
....	21	29%
....	19	16%
....	15	27%

The measurements which exhibit the smallest difference (No. 28), represent roughly the distances of the apices of the temporal lobes of the brain. The greatest differences are shewn by the base of the brain in the region of the pons and anterior part of the medulla (No. 39); by the exits of the optic nerves (No. 25); by the region corresponding with the outer sides of the frontal lobes (No. 21); by the region corresponding with the outer sides of the parietal lobes, or the posterior and upper parts of the temporal lobes (No. 15); and by the width of the basicranial axis itself.

It will be very interesting to ascertain, from similar measurements of other skulls, to what extent the rule observed in these, that in skulls with equal basicranial axes[1] *dolichocephali* are absolutely narrower than *brachycephali* in their transverse diameters, holds good. Even in the present cases there is the remarkable exception with regard to the transverse diameters of the occipital (No. 10), which has already been noted; and it is, of course, quite conceivable that the diameters of the base of the cranium should vary irrespectively of those of its side walls. But a skull which should derive its excess in breadth from a development of its side walls alone, exhibiting what might be called *lateral brachycephaly*, would obviously have a

[1] In comparing skulls the lengths of the respective basicranial axes must be carefully taken into account. Had the basicranial axes of *A* and *B* been unequal I should have given all the measurements of each skull in terms of its own basicranial axis; but, as they are equal, I have not thought it worth while to take the trouble of making the requisite calculations.

different significance from one which, like A, is, *basally*, as well as *laterally, brachycephalic*. And similar considerations apply to *dolichocephaly*.

4. By 'vertical height' in the foregoing table of measurements, I mean the distance from the posterior and inferior end of the basicranial axis to the point of intersection of the coronal and sagittal sutures. These are convenient fixed points, and although a line joining them is by no means constantly perpendicular to a longitudinal axis of the skull, or inclined at any invariable angle to the basicranial axis, yet, practically, it hardly ever differs more than a tenth of an inch from a more strictly vertical measurement.

The vertical height of B exceeds that of A by about $10\frac{0}{0}$; but while A is within 0·1 inch as low as any skull I have met with, B is not more than half way towards the maximum of height which I have observed, and which is about an inch greater than that of B.

The following table of a few measurements of sections of crania seems to shew that the height of skulls as thus estimated, varies without much reference to their other measurements.

		Length of the basicranial axis.	Height.	Cephalic index.
1.	Scutari (Turk? 5563 A)	245	575*	·88
2.	Japanese........................	290	570	·75
3.	Redondo (Negro)	275	570*	·72
4.	Australian (5317)	250	565	·68
5.	Tasmanian (5324)	225	550	·76
6.	English (5733)	250	550	·74
7.	Japanese........................	272	550*	·75
8.	Australian (5307)	250	545	·69
9.	The skull B	235	530	·629
10.	Australian	230	530	
11.	Chinese (5474)	235	535*	·75
12.	Malay (5463 A)	240	510*	·88
13.	Japanese	240	490*	·76
14.	Australian (5331)	?	490	·71
15.	Mondombe (Negro)	230	480	·74
16.	The skull A	235	480	·977

*** The * indicates that the height of the parietal region exceeds that given by about 0·1 inch. The remarkable length of the basicranial axis in Nos. 2, 3, and 7 must be taken into account. The numbers refer to the Catalogue of the Museum of the Royal College of Surgeons.

5. Certain important differences between the skulls A and B, which would not be brought out by the ordinary methods of measure-

ment and comparison, become very obvious in the sectional diagram (Fig. 9). Thus, the spaces behind the lines *Cv, Cv,* and in front of *f, k, f, k* are very much greater in *B* than in *A*, shewing that the cerebral hemispheres overlapped the cerebellum behind and the cerebrum in front, for a much greater distance in *B* than in *A*. The distance between the anterior contour of the cranial cavity and the anterior end of the basicranial axis in *B* is further increased by the greater length of the cribriform plate *a, f.* Hence, if we call the space comprised between the lines *a, h, a, f,* and the anterior inner contour of the frontal bone, the *frontal area* of the longitudinal section, this *frontal area* is absolutely greater and projects further forwards in *B* than in *A*. The difference between the two skulls thus produced is further exaggerated by a sort of rotation of the whole cranial chamber upon its axis, forwards in *B* and backwards in *A*. Thus the whole forehead, with the coronal suture, is thrown backwards in *A*, and the occipital plane, partaking in the same movement, forms a more open angle with the basicranial axis than that of *B*. The tentorial plane has shifted in the same sense to a less degree. The line *b, i,* in *A*, on the other hand, is a little in advance of the corresponding line in *B*, probably in consequence of the remarkable brevity of the parietal bones.

The skulls *A* and *B* present as complete a contrast as any I have seen in regard to this remarkable rotation of the skull upon its basal axis. But it must not be supposed that the backward rotation is connected with brachycephaly, or the forward rotation with dolichocephaly. I have sections of two dolichocephalic Australian skulls which differ as widely as *A* and *B* in the anterior region of the skull. I have other sections of brachycephalic skulls, in which the frontal contour lies far in advance of that of *A*, though I have not yet met with a brachycephalic skull having so great a forward rotation of the frontal region as *B*.

As a rule, the coronal suture is situated forward with forward rotation of the skull; backward, in the contrary case. But neither the lambdoidal suture, nor the posterior edge of the occipital foramen, necessarily follows it. In a negro skull, with nearly the same extent of backward rotation of the frontal region as in *A*, the line *b c* makes an angle of only 135° with *a b*, or 26° less than in the case of *A*.

The influence of the backward and forward rotation of the frontal region of the skull upon orthognathism and prognathism, as they are ordinarily estimated, is obvious. The so-called *facial angle,* in fact, does not simply express the development of the jaws in relation to the face, but is the product of two factors, a facial and a cranial, which vary independently. The face remaining the same, progna-

thism may be indefinitely increased, or diminished, by the rotation of the frontal region of the skull, backwards or forwards, upon the anterior end of the basicranial axis.

If *B* had the frontal contour of *A*, it would be an extremely marked example of orthognathism, or rather of what Welcker has called "opisthognathism;" while, if *A* had the frontal contour of *B*, it would appear to be marvellously prognathous. And yet in neither case would there be any change in the jaws, but only so much modification in the position of the cranial cavity relatively to its axis, as can be shewn to occur among skulls belonging to the same stock.

6. The real differences in the disposition of the facial bones relatively to the basicranial axis, or, in other words, the amount of true *prognathism* or *orthognathism*, cannot, in fact, be safely estimated by any of the accepted "facial angles." The sectional diagram shews that *B* is truly much more prognathous than *A*, the differences between the two being of three kinds.

(*a*) The vertical height of the nasal cavity is somewhat less in *B* than in *A*.

(*b*) The length of the palate is greater in *B* than in *A*.

(*c*) Lines drawn from the anterior end of the basicranial axis to the posterior and anterior margins of the floor of the nasal cavities (*a e*, *a d*) form more open angles (*premaxillary* and *postpalatine angles*) with *a*, *b* in *B*, than they do in *A*. In other words, the centre of the palate has, so to speak, moved forwards in *B*.

Increase in the absolute length of the palate and shifting forward of the centre of the palate, are competent, singly or together, to produce true prognathism, other conditions remaining unaltered. But shortening of the vertical height of the nasal chamber alone is consistent with the preservation of complete orthognathism. As a general rule, however, the three conditions are concomitant, as in *A* and *B*; the more prognathous skull having a lower nasal chamber as well as a longer palate, and a shifting forward of the centre of the palate.

Practically, I should say that the angle *b*, *a*, *d* fairly represents the degree of true prognathism; and I think it will be found convenient to consider skulls in which that angle is less than 95° as orthognathous, and those in which it is greater as prognathous. The most prognathous skull I have met with had the angle *b*, *a*, *d* = 110°; in the most orthognathous it was only 83°. I doubt if the angle ranges much beyond 30°.

7. The vertical measurements of the face (Nos. 2, 3, 5, 46, 48) either agree, or differ but little, the excess being in favour of *A* (Nos. 46, 48). Among the longitudinal measurements, those of the palatine plates of the palatine bones agree (No. 7), shewing that the

difference in the lengths of the palates is wholly due to the premaxillæ and maxillæ. Again, the lengths of the zygomata differ only to an inconsiderable extent, whence it follows that the excess of longitudinal growth is in the alveolar, rather than in the orbital parts of the maxillæ. No. 42 shews that the margin of the premaxilla is ·88 inch more distant from the lower end of the basicranial axis in *B* than in *A*; but No. 43 proves that 0·28 of this amount is due, not to the excessive growth of the maxilla and premaxilla, but to the shifting forward of the palate as a whole.

8. Taking the length of a line *A*, *B*, drawn from the anterior alveolar margin of the premaxilla along the posterior edge of the occipital foramen and cut by a perpendicular tangent to the posterior face of the occiput, to represent the basal length of the whole skull (No. 50), it is much longer (1·5 inch) in *B* than in *A*. Nevertheless, the extra length of *B* is so distributed that the centre of the occipital foramen (x) is in exactly the same place in the two skulls, viz. at three-fifths of the length of the line *A*, *B* from its anterior end.

9. Although *A* is cryptozygous and *B* phænozygous, the interzygomatic width of the face is greater in *A* than in *B* by about 12$\frac{0}{0}$ (No. 41). But the maxillary diameter (No. 44), on the contrary, is about 9$\frac{0}{0}$ greater in *B* than in *A*. This arises, however, chiefly from the less development of the alveoli themselves in *A*, seeing that the breadth of the palate inside the alveoli (No. 7) is the same in the two. The distances of the suborbital foramina (No. 12) are nearly the same in the two skulls, and those of the upper ends of the ascending processes of the maxillary are identical. Hence the greater width of the face in *A* is not due to any excess in the size of the bodies of the maxillary or premaxillary bones, but to the increased transverse diameter of the frontals (Nos. 19, 20), which push the jugal bones outwards. This is accompanied by a certain increase in the diameter of the ethmoid (Nos. 23, 24), of the distance between the optic foramina (No. 26), and of the width of the posterior nares (No. 47).

10. In describing the general characters of the two skulls I have mentioned the interesting fact that the chief sutures of *B*, the very long skull, are completely open; but that the sagittal suture of *A*, the very short and broad skull, is thoroughly obliterated, while the other great sutures named are still open.

It is therefore clear that extreme brachycephaly is consistent with comparatively early synostosis of the parietal bones; or, in other words, that synostosis of those bones may take place comparatively early and yet have no discernible effect upon the form of the skull.

This is, in fact, perfectly obvious from the nature of the case.

For the final proportions of the brain-case of the human skull are attained in early manhood, while the sagittal suture ordinarily remains open till late in life; and it can make no manner of difference to the shape of the brain-case whether the sagittal suture becomes obliterated at thirty, or at fifty, years of age, if the brain-case assumes its final proportions at twenty-five.

When the skull of a man of middle age, of unknown stock, with obliterated sagittal suture, is placed before an anatomist, he possesses absolutely no evidence respecting the period at which the obliteration took place; and, consequently, he has no means of judging whether the synostosis has, or has not, had any share in producing the form of the skull. If the cephalic index of the skull be greater than ·70, he has not the least right to suppose that the synostosis has had any effect, inasmuch as there is abundant evidence to prove that crania with lower cephalic indices exhibit no such synostosis.

The Neanderthal skull belongs to a man of middle age, is of unknown stock, and has a cephalic index of ·72. There is consequently not a shadow of justification for the assumption that any obliteration of the sagittal suture which it presents has had more effect in narrowing its proportions, than the obliteration of the sagittal suture in *A* has had upon the configuration of that exceedingly broad skull[1].

[1] With the permission of the Museum Committee of the Royal College of Surgeons, and of Mr Sedgwick, casts of the skulls *A* and *B* and of their cavities, representing the corresponding brains, have been made and are to be obtained of Mr Gregory, Russell-Street, Covent-Garden.

ON A REMARKABLE MODE OF GESTATION IN AN UNDESCRIBED SPECIES OF ARIUS (*A. Boakeii*). By WM. TURNER, M.B. (Lond.) F.R.S.E., *Senior Demonstrator of Anatomy, University of Edinburgh*[1].

THE various plans resorted to by fish of depositing their ova, and protecting them during the period of incubation, have not unfrequently attracted the attention of naturalists. One of the most curious and interesting observations made on this subject was brought before the Boston Society of Natural History, about nine years ago, by Dr Jeffries Wyman. He states[2] that when walking through the market of Paramaribo, in Dutch Guyana, he found the mouths of several species of Siluroid fish belonging to the genus Bagrus, or to one closely allied, distended with ova, sometimes between twenty and thirty in number. The eggs were in various stages of development, some recently deposited, others with the embryo very considerably advanced. The eggs were always in the mouths of males, and were not bruised, and none were found in the stomach. In the fifth volume of his Catalogue of Fishes in the British Museum[3], Dr Günther relates that, whilst examining some specimens of *Arius fissus* from Cayenne, presented to the Museum by Professor Owen, he was surprised to find their mouths and gill-chambers distended with about twenty eggs rather larger than an ordinary pea. The eggs were perfectly uninjured, and the embryoes in a forward state of development. These specimens were also males. Again, Professor Agassiz, writing from the river Amazon, September 22, 1865[4], states that he has observed a species of Geophagus, *G. pedroinus,* a fish belonging to the family Chromidæ, in which the mouth and a pocket-like pouch, formed by the superior pharyngians, contained a number of ova. How the eggs get into the mouth he is quite ignorant; but there they remain until the young are in a fit state to take care of themselves. In all the above cases the fish are denizens of the South American continent; and, except the species described by Agassiz, belong to the Siluroid family.

The observations to which I shall now direct attention prove that this remarkable egg-carrying habit is not confined to certain species of fish dwelling in the new world, but is shared by some of the fish of the old world also. In the month of April of the present year I received for examination, from the eminent botanist, the late Dr Greville, some specimens of Siluroid fish, which had been sent him

[1] Read before the British Association for the Advancement of Science, August 23, 1866.

[2] *Proceedings of Boston Society of Natural History*, Sept. 15, 1857, and *American Journal of Science*, Vol. LXXVI. 1859.

[3] London, 1864.

[4] *Quarterly Journal of Science*, p. 302. April, 1866.

by the Rev. Barcroft Boake, of Ceylon. The specimens were accompanied by a copy of the literary supplement to the *Ceylon Examiner*, to which Mr Boake had communicated "An account (dated April 20, 1865,) of some peculiarities in the habits of certain species of fish that are found in the waters of Ceylon." The most interesting portion of this narrative consists of an account of the habit of a fish caught at Caltura in that island. When held up by the tail it emits from the mouth a quantity of eggs, which, when many fish are captured, are fried, and used for food by the natives. The fishermen suppose that the regular mode of bringing forth the young is through the mouth; but Mr Boake satisfied himself that the fish produce their eggs in the ordinary way; and that, after being deposited, they are immediately taken into the mouth, either by the fish that has laid them, or by another of the same species, where they are kept until they are hatched.

The specimens given to me were two males and one female. The female had no ova in her mouth; but from the appearance of the abdomen it was evident that the ovaries were distended; and on opening into the cavity I found a large sac-like ovary on each side of the middle line. Each ovary measured $2\frac{1}{2}$ inches in length, and extended forwards almost as far as the pectoral fin, where it formed a rounded free end, whilst posteriorly it was somewhat constricted, and opened by an orifice common to it and its fellow immediately behind the anus. The ovisac contained a very large number of eggs in various stages of growth; some were like minute granules, others, and these were very numerous, like medium-sized shot, whilst a third set equalled in size grapes or small cherries and very materially exceeded therefore the size usually attained by the eggs of osseous fish. These last, only six in number in each ovary, had evidently almost reached the full period of intra-ovarian growth. Each ovum was attached to the inner wall of the ovisac by an independent pedicle, the atrophy of which would necessarily precede the discharge of the egg.

The mouth and branchial chamber of one of the male fish were distended with ten ova as large as those found in the ovarium, which were so closely packed together that water, or minute particles of food, could only pass backwards to the gills or œsophagus by filtering through the narrow interspaces between the eggs. In each ovum the development of the embryo had advanced so far that the eyes, chorda dorsalis, and cerebro-spinal nervous axis, could without difficulty be distinguished, and from the ventral surface of the embryo numerous vessels were seen ramifying over the surface of the yelk. The embryoes measured from $\frac{1}{2}$ to $\frac{7}{10}$ths of an inch in length. Only one of the ten eggs had sustained any injury, its investing membrane

being ruptured, so that a portion of its contents had escaped. It is interesting to note that the palatine teeth of the fish are granular, so that their form is well adapted for permitting the retention of the ova in the mouth with a minimum of injury.

Mr Boake's observations show that the eggs are not placed in the mouths of the fish by the natives for purposes of deception, but that the instinct of the animal prompts it to take them into that cavity; and it is, as these specimens show, by the male, and not by the female, that this act is performed. In this respect this Cingalese fish agrees with those already described by Drs Wyman and Günther. Opinions may differ as to the reason of this remarkable habit. It may be supposed that the male uses the eggs for food, or that he takes them into his mouth for temporary protection, discharging them again when the danger no longer exists, or that their presence in that cavity is connected with the process of incubation. The last of these suppositions seems to me most probable, for the habit of distending the mouth with eggs appears to be so common in this species of fish, that it is a matter of ordinary observation amongst the natives; the eggs are not torn or bruised as they would have been if subjected to the process of mastication, the stomach does not contain any fragments, and in each ovum is situated an embryo in a more or less advanced stage of development. Again, naturalists are acquainted with other fish which play a part in the incubation of their ova; the male pipe-fish, the male hippocampus, and the *Aspredo lævis,* described by Wyman, possess special arrangements for receiving and carrying about the eggs until they are hatched. A close relation apparently exists between the number of eggs which come to maturity at a given time, and the number which the male can carry in his mouth. In the female I examined twelve eggs are evidently reaching their full growth, whilst the male has ten in his mouth; and from another specimen examined by Mr Boake, as many as thirteen were shaken out. This is a smaller number than was observed by Drs Wyman and Günther in their Siluroids, but the eggs are in this species of much larger size. As the distended condition of the mouth would necessarily materially interfere with the reception of food by the male fish, it may be a question if he does not eject them during feeding, or perhaps during the time he plays the part of a dry nurse the quantity of food he takes may be almost *nil.*

The following are some anatomical and zoological details.

Stomach pendulous in abdomen and empty. Duodenum curved from left to right, then passed backwards and succeeded by the convolutions of the small intestine, behind which the gut again became

straight on its course to the anal orifice. Liver consisted of two almost symmetrically placed lateral lobes united by a median isthmus lying below the œsophagus. Gall-bladder to the right in the interval between the liver and duodenal curve, its duct arched to the left side, almost parallel to the duodenum, into which it opened, just above the pyloric end of the stomach. Spleen of a triangular form, not connected with the stomach, but situated on the left of the convoluted small intestine. Kidneys placed at posterior part of abdomen in close relation to swimming bladder, each terminated anteriorly in a pointed end, whilst posteriorly they blended together behind the swimming bladder, and formed together a crescent-shaped mass; at the point of junction a tongue-like process passed backwards, and out of this two opaque white ureters proceeded, which joined almost immediately and formed a single and much wider canal which opened posteriorly behind the oviduct. Testicles a pair of elongated glands, somewhat more than an inch long, separated by a peritoneal fold anteriorly, but lying side by side in their posterior halves, and extending backwards between the rectum and ureter to their termination. The swimming bladder was a capacious sac, which occupied a large extent of the dorsal part of the abdomen. It was imperfectly subdivided into alveoli by an antero-posterior and several transverse septa, the former terminated in front in a crescentic margin, so that the lateral halves freely communicated anteriorly. From the middle line of the ventral surface of the swimming bladder a short duct proceeded, which passed to the dorsal wall of the œsophagus. In the interval between the anterior end of the swimming bladder and the branchiæ was a soft greyish gland-like mass, which possessed a transverse diameter of nearly one inch. It was enclosed in a delicate capsule, and subdivided into a number of granular lobules. Examined microscopically these lobules were found to consist mainly of colourless corpuscles, like those entering so largely into the structure of the thymus, from which circumstance, whether we apply to it the descriptive name of thymus or not, it ought to be referred to the group of glands of which the thymus and suprarenal capsules are such well-known representatives.

The fish belongs to the genus *Arius*, but as it differs in some of its characters from the species already recorded, an opinion in which I am supported by the high authority of Dr Günther, to whom I showed the specimens in the month of June, I purpose describing it as a new species, and to connect with it the name of the gentleman by whom it has been sent to this country[1].

[1] Dr Günther writes me that since I showed him my specimens he has examined a collection of fish from Ceylon recently sent to the British Museum, and finds that not only does it contain *A. Boakeii*, but another species of egg-bearing *Arius*.

Arius Boakeii. D. 1/7, A. 19, P. 1/10.

Body, without caudal fin, five times longer than high, and between three and four times longer than the head. Breadth of head somewhat more than its height, its greatest breadth nearly $\frac{2}{3}$rds its length. Upper surface of head finely granulated, and divided into two lateral halves by a smooth, narrow, lanceolate groove, which extends quite as far back as the base of the occipital process. Occipital process triangular, lateral margins straight, longer than broad, and with a fine keel along the middle. Each half of the intermaxillary band of teeth rather more than twice as broad as long. No vomerine teeth. Palatine teeth granular, arranged in two distinct patches of a triangular form with rounded angles: posterior margin or base of the patch concave, outer margin convex, inner almost parallel to its fellow posteriorly, but diverges from it anteriorly. Maxillary barbels pass beyond the base of the pectoral spine. Dorsal spine strong and serrated on both margins, about equals the height of the body, though the fin is prolonged much higher through a slender filamentous process just behind the spine. Adipose fin short with black patches. Caudal fin deeply forked: lateral line bifurcating at root of caudal fin. Pectoral spine not so long as the head: it equals in length the dorsal spine, and extends slightly beyond a vertical line drawn from the last ray of the dorsal fin. External mandibular barbel passes as far back as the gill-cleft. Sides of body silvery. Male carries developing ova in mouth.

Length of male without caudal fin.........6·4 inches.
.... female ....7·5 ......
Habitat, Ceylon.

ON A VARIATION IN THE ORIGIN OF THE LONG BUCCAL NERVE AS ELUCIDATING ITS PHYSIOLOGY, by WM. TURNER, M.B. (Lond.), F.R.S.E.

ANATOMISTS and physiologists by no means agree in the statements which they make respecting the function of the long buccal branch of the inferior maxillary division of the fifth cranial nerve. From the circumstance that it apparently arises from the smaller of the two primary subdivisions of the inferior maxillary trunk, along with the nerves which undoubtedly supply the muscles of mastication, and that it enters the substance of the buccinator muscle, some have regarded it as the motor nerve of supply for that muscle (Sir C. Bell, J. Müller). Others, again, having traced branches proceeding from it, partly to the buccinator muscle itself, and partly to the glands and mucous membrane of the cheek, consider it to be both a motor and sensory nerve, its motor fibres assisting the portio dura of the seventh in the supply of the buccinator muscle. This view has been supported by various writers, and most recently by the late Dr Todd in his Clinical Lectures[1]. Thirdly, the buccal nerve is regarded as purely sensory in its function, as contributing no motor fibres to the buccinator muscle, which is therefore supplied solely by the portio dura of the seventh. This view is based on anatomical investigation, on physiological experiment, and on pathological observation. On one, or other, or all of these grounds, it has been advocated, amongst others, by Mayo, Volkmann, Longet, Alcock, Paget, Kirkes, and Sanders.

Of these different opinions as to its function the third is undoubtedly the one which is based on the most satisfactory evidence. Dr Alcock[2] traced the fibres which form the facial portion of the buccal nerve up to the ganglionic (sensory) root of the third division of the fifth. Mayo first pointed out that irritation of this nerve produces no action on the muscle, and the general result of pathological observation has been to prove that when the muscles of mastication, which are supplied by the non-ganglionic (motor) part of the fifth nerve, are paralyzed, the buccinator still performs its functions; whilst, on the other hand, loss of power of the buccinator accompanies paralysis of the portio dura of the seventh.

A case has recently come under my observation, which supplies an additional proof, and from a different point of view to those hitherto advanced, in favour of the purely sensory function of the

[1] 2nd Edition, edited by Dr Beale. 1861.

[2] Todd's *Cyclopædia*, Vol. II. p. 304. Article Fifth pair of nerves.

long buccal nerve. About the middle of last winter session one of my pupils, Mr Edwin Thompson, whilst dissecting the nerves on the left side of the face, observed that the mode of arrangement of the buccal nerve differed from the description in the text books. He requested my attention to his dissection, when I found the very remarkable variation in the mode of origin of the buccal nerve which I shall now describe. From the smaller of the two primary subdivisions of the inferior maxillary nerve branches arose which passed in the usual manner to supply the masseter, temporal, and two pterygoid muscles, but no buccal branch proceeded from it. When the surface of the buccinator muscle was exposed, a nerve was however seen to pierce it at the customary spot, and when this was traced to its origin, it was found to ascend in close relation to the posterior part of the outer surface of the superior maxilla as far as the spheno-maxillary fossa, where it took its rise from the superior maxillary or second division of the fifth nerve. At its origin it was blended with the posterior dental branch of the same nerve, which, after a short course, separated from it to enter a canal in the upper jaw for the supply of the molar teeth.

As the superior maxillary nerve is purely sensory in its function, the branches which proceed from it necessarily partake of the property of the parent trunk. But as it might have happened that in this case the motor root of the fifth, instead of expending itself wholly on the inferior maxillary nerve, might have given a branch within the cranium to the superior maxillary after its origin from the ganglion, and so have communicated to that trunk motor fibres, I carefully dissected the ganglion and nerves proceeding from it, and satisfied myself that the whole of the motor root in the usual way attached itself to the inferior maxillary trunk. Hence there could be no doubt that in this case the long buccal nerve on the left side was purely sensory. We may then, I think, accept the variation in the origin of the nerve exhibited in this individual as a dissection by the hand of nature herself, which affords a key to the determination of the function of the nerve, and confirms in a striking manner the results which had previously been arrived at by the minute dissection of the anatomist, by physiological experiment and pathological observation. What the arrangement of this nerve on the right side of the same subject may have been I am unable to say, as the parts had been so far removed, before my attention was called to the dissection, that its connections could not precisely be determined.

ON THE ACTIONS OF MUSCLES PASSING OVER MORE THAN ONE JOINT, by JOHN CLELAND, M.D., *Professor of Anatomy and Physiology, Galway.*

THE muscles of the limbs are easily grouped into those which pass over one joint each, and those which pass over more joints than one; which latter may for brevity be called long muscles. The long muscles are functionally divisible into three sets, not quite distinct one from another. Some habitually produce movement in one continuous direction in all the joints over which they pass, as for example the flexors and extensors of the fingers, the short flexor of the toes, and the pectoralis major; others cause simultaneous movement in opposite directions to take place at different joints which they influence; and to this group the sartorius, the lumbricales, and the dorsal interossei belong[1]: while a third set may be distinguished as consisting of muscles which, although calculated to cause motion in one direction at the different joints over which they pass, are yet in the ordinary gestures of the body so combined in action with other muscles that when at one of those joints there is movement in one direction, at the other there is movement in the opposite. It is to this last set of muscles, including the biceps and long head of the triceps of the arm, the gastrocnemius, the hamstring muscles, &c., that the following remarks refer.

The peculiarities of these muscles first attracted my attention, while making dissections of the horse, nearly four years ago; and I briefly brought them under the notice of the physiological section of the British Association at Newcastle.

The coraco-radialis muscle of the horse, corresponding with the biceps of the human arm, is a tough and compact muscle nearly incased in a tendinous sheath, and divided by numerous tendinous septa arranged longitudinally within it. To these are attached its short oblique muscular fibres, arranged in compound pennate fashion and extremely numerous, but varying in length from so short an extent as a quarter of an inch to not much more than half an inch: and in the centre of the muscle is imbedded a strong ligament which passes uninterruptedly from the scapular to the radial attachment. From near the lower end of this ligament a tendinous slip, corresponding with the semilunar fascia of the human subject, passes downwards in

[1] The peculiar action of the lumbricales and dorsal interossei muscles in at once flexing the proximal phalanges and extending the others, mentioned by Hunter (*Collected Works*, Vol. IV. p. 237), is very frequently overlooked. My attention was drawn to it by Professor Goodsir.

front of the radius to the great extensor of the metacarpus, and, continuing on the surface of that muscle, goes on to join its inferior tendon. There is thus completed an uninterrupted fibrous connection between the scapula and the cannon bone; and although the lower of the two bands which form it is nothing more than a strong aponeurosis, yet its existence is sufficient to show that those limits to movement which it determines in the dissected limb existed in life. By means of the brachial ligament described, flexion of the shoulder causes a corresponding amount of flexion of the elbow; and extension of the elbow causes extension of the shoulder: also the upper extremity of the tendon to the cannon bone being pulled upward in each extension of the elbow, the carpus is pulled into the extended position at the same time.

The whole arrangement belongs to a mechanism by which the weight of the body is supported on the straight limb without the aid of muscular contraction. Thus when the shoulder and elbow-joints are being extended in setting the limb to the ground, the band to the cannon bone ensures the simultaneous extension of the horse's knee: once on the ground, that joint and the joints below are kept extended by their construction and the pressure from above; but the flexors of the carpus are so short as to admit of very little flexion of the elbow when the knee is extended; they therefore support the humerus when its upper extremity is pressed on from above; and this they do, not by active contraction, but in virtue of their shortness; the coraco-brachialis and its contained ligament, maintain without muscular contraction, the proper amount of extension of the shoulder as long as the elbow is extended; and lastly, the weight of the thorax is suspended between the scapulæ principally by means of the serrati magni muscles, without these muscles being necessarily actively contracted.

In the hind limb of the horse arrangements of the same description exist. Thus the flexor pedis perforatus, which is attached superiorly above the condyles of the femur, has its muscular fibres still shorter and more separated by tendons than the coraco-radialis; the length of fibre being about a quarter of an inch, and the arrangement such that the total shortening of the whole muscle cannot exceed that of a single fibre; and in front of the leg a ligament in connection with the flexor metatarsi binds the femur and metatarsus so closely together that flexion of the stifle joint compels flexion of the hock to a corresponding extent. In fact, the advantages of construction which the horse's limbs exhibit for the production of the series of movements required by the animal's habits, are obtained by means which involve a narrow limit to the variety of movements; some of the muscles being associated with ligaments, and restricting

motion as much as mere ligamentous bands would, while others more or less approach the same disposition.

But the limit of motion by the shortness of muscles is not an arrangement confined to one animal, although perhaps in the horse the principle is carried to a greater extent than in any other. The elbow of the cat can be bent by moving the shoulder-blade. In birds, extension of the elbow compels extension of the metacarpus; the extensor carpi radialis being too short to admit of the metacarpus remaining flexed when the elbow is extended, and the humeral attachment of the muscle thus drawn further from the radius. Also, in perching birds, the flexion of the metatarsus on the leg, caused by the weight of the body, is sufficient to produce flexion of the phalanges, so that the bird grasps its perch with little muscular exertion.

Instances of the same description of interdependence of joints are observable in the human body. Few persons, if any, can combine complete flexion of the hip with extension of the knee, the hamstring muscles being too short to admit of it; and therefore flexion of the hip-joint ought to be avoided by the surgeon, where maintained extension of the knee-joint is desirable. When the knee is bent the foot can be flexed on the leg to an extent which, when the knee is extended, the gastrocnemius prevents; and in a limb severed from the trunk the straight knee can be bent by pushing up the front of the foot. If the wrist be overextended, and it be then sought to straighten the fingers, it will be found that movement forwards at the wrist will take place in the attempt. It is to be observed, however, that although in these various instances certain combinations of attitude in neighbouring joints are prevented, it is seldom, if ever, that in the natural movements of the body this property of muscles is brought into play. It is only by putting the limbs in positions uncomfortable, unusual and useless, that the shortness of the muscles is discovered. Thus, for example, the shortness of the hamstring muscles is illustrated by the difficulty of accomplishing one of the feats demanded of men on drill, namely, to touch their toes with their fingers, while the knees are kept straight; but this position is one which would never be assumed for any practical purpose, and although it may be ingeniously fitted for the torture of apoplectic soldiers, it is not likely to give freedom of movement in the proper use of the joints; being only calculated to stretch the hamstring muscles to a greater length than usual, which has not been shown to be any advantage.

The combinations of movement most frequently observed in the human limbs are of precisely the same nature as those which are the only movements allowed in the limbs of the horse. Thus in the usual gestures of the arms, whether in grasping or rejecting, the shoulder

and the elbow are flexed simultaneously, and simultaneously extended; and even in suddenly throwing the arms forwards when they are hanging at rest by the side, the natural movement is not to swing them forwards at once from the shoulder, but to flex the shoulder and elbow-joints, then dart both arm and forearm forwards together, in the same way as in rowing. Thus also with regard to the lower limbs in running, as well as in rising and sinking on the straightening and bending legs, the hip, the knee and the ankle are extended and flexed together; and this is also the case in walking, except in that part of the process in which the limb is thrown forwards in front of the body. But in straightening the elbow and throwing forward the shoulder together, the biceps muscle is pulled upon at the elbow, while the arm at the shoulder moves as if yielding before that muscle; and the straightening of the elbow approximates the attachments of the triceps muscle, while the simultaneous extension of the shoulder increases the distance over which the long head of the triceps is stretched at its upper end. Similarly to this, in the movements of walking, the hamstring muscles, the rectus femoris, and the gastrocnemius are not alternately stretched and contracted; but as each has its distance over one joint shortened, it has the distance over which it passes at the other joint increased.

What then is the action of all these muscles in movements of the sort described? In the foreleg of the horse the whole shortening of the coraco-radialis, supposing that muscle to contract either in aid of extension of the shoulder or flexion of the elbow, is certainly less than half an inch; and a shortening of half an inch will produce scarcely any movement in the limb of so large an animal as a horse. In like manner, the flexor perforatus of the hind-limb can produce hardly any effect by mere change of length, seeing that the extent of its possible contraction is less than a quarter of an inch. But while it is obvious that these short-fibred muscles are not the active elements which produce extensive movements in the joints over which they are placed, a little reflection will make it clear, that whatever the length of fibre of the muscle whose action we consider, if the movements of the limb resemble those of the horse in being of such a description that the attachments of the muscle, instead of approaching and separating, remain at a pretty uniform distance throughout, that muscle cannot be the moving agent. And this is a case which actually occurs. Thus I have made measurements of the distance from the superior to the inferior attachment of the gastrocnemius muscle, when both knee and ankle were completely flexed, and when they were both completely extended, and have found that the distance remains unchanged. If we sink upon the bended knees, flexing the limbs completely and remaining balanced on the toes,

then rise to our full height on tip-toe, the length of the gastrocnemius remains unchanged in the movement. Therefore the belief that this muscle acts similarly to the soleus, and in conjunction with it, is altogether erroneous; and it may be truly said, that had no other movements been required than those involving uniform relation of ankle and knee, a ligament would have served the purpose of the gastrocnemius muscle.

Let us suppose the semimembranosus muscle, the rectus femoris and the gastrocnemius to be each replaced by a ligament, and let the semitendinosus and biceps be left, for simplicity's sake, out of consideration. In bending the limb, the hip-joint being flexed by the ilio-psoas, the knee would be compelled to bend by the semimembranosus preventing the upper end of the tibia increasing its distance from the ischium, and, in the case of the limb being free, the ilio-psoas would have thrown upon it the muscular effort required to bend the knee as well as the hip. On the other hand, if the limb were bent beneath the weight of the body, the gastrocnemius, being pulled down by the flexion of the ankle, would drag down the thigh, and the rectus femoris stretched over the bent knee would pull forwards the pelvis, and so flex the trunk on the femur; and thus flexion of the ankle would compel flexion of the hip-joint. In straightening the limb, the soleus, the vasti and crureus, and the gluteus maximus would continue to extend the ankle, knee and hip respectively; but while the action of the soleus would be confined to the ankle-joint, because in the human subject, contrary to what is the case in quadrupeds, no muscle of the dorsum of the foot extends over the knee to the femur, the action of the other muscles enumerated would not be confined to the joints over which they pass. For the extension of the thigh from the hip by the gluteus maximus would drag the knee straight by pulling upwards the rectus femoris, and the straightening of the knee would extend the foot by dragging upwards the gastrocnemius. So also contraction of the vasti and crureus would act on both ankle and hip-joint by dragging up the gastrocnemius and pulling down the semimembranosus. Now it is easy to perceive that effects such as we have been supposing to be produced by ligaments are actually produced habitually by muscles. This is obviously the case wherever the points of attachment of a muscle remain without alteration of distance throughout a movement of the limb; it is obvious also when the points of attachment become further removed one from the other during the movement; and even where there is shortening of the muscle, there is a mixture of the same ligamentous action whenever the more fixed attachment is dragged in a direction away from the point occupied, at the commencement of the movement, by the more mobile attachment.

I think that I have now made it very plain that the action of the hamstring, rectus femoris, and gastrocnemius muscles in the lower limb, and of the biceps and long head of the triceps in the arm, is in the ordinary series of movements chiefly of a ligamentous character, and that action of the same description enters as an element combined with true muscular action in the accomplishment of movements by other muscles.

One effect of ligamentous action of long muscles is *to give to short muscles an indirect action on joints over which they do not pass.* Thus if the rectus femoris remain tonically of such length that when stretched over the extended hip it compels extension of the knee, then the gluteus maximus becomes not only an extensor of the hip but an extensor of the knee as well. Such indirect action may either come into operation to make muscles which attach limbs to the body efficient in moving distant joints in the neighbourhood of which it would be inconvenient to have large masses of muscle, or may cause the action of two groups of powerful short muscles to be effective on one or other joint as may be required. The first of these advantages is illustrated in the limbs of horses, and still better in the wings of birds, in which the powerful pectorales muscles and their antagonists, largely developed and lying against the body, are made the motor agents of all the joints of the wing, which are thus left comparatively unincumbered with the weight and bulk of muscle. The other principle is illustrated in the lower limbs of man, for if the gluteus maximus act on the knee-joint through the rectus, and the vasti and crureus on the hip-joint through the hamstring muscles, then the total amount of muscular power is made available for overcoming the total amount of resistance, whichever be the joint on which that may to the greatest extent fall.

The action of muscles thus ligamentously employed differs, however, in various respects from that of mere ligament. Taxed beyond its strength a ligament will be ruptured, whereas a contracted muscle is easily relaxed: also, if neighbouring joints be united by ligaments, the amount of flexion or extension of each must remain in constant proportion to that of the other; while, if the union be by muscles, the separation of the points of attachment of those muscles may vary considerably in different varieties of movement, the muscles adapting themselves tonically to the length required. In these circumstances sufficient reason is to be found for the employment of an organic action involving waste of tissue and energy, instead of bands with mere mechanical strength; and it is also to be recollected that a truly motor action is often combined with the ligamentous, and that occasionally the muscles, whose ligamentous function is most marked, are called on to act in a wholly different manner from that in which

they usually do, passing at once from greatest contraction to greatest stretch. For example, a movement of this description occurs in the arm in the wielding of a sabre or sledge-hammer; for if the elbow be flexed and the hand thrown behind the head, both elbow and shoulder are placed so as to approximate the attachments of the biceps; and when the arm is then thrown forwards, the shoulder brought down, and the elbow extended, the biceps is stretched over both joints, while the long head of the triceps has its attachments suddenly approximated. So also, in the lower limb, in the movement of kicking, the hamstring muscles have their attachments at first approximated by overextension of the hip and flexion of the knee, then when the limb is swung forwards they are placed on full stretch, and the rectus femoris has its attachments approximated. Both of the movements mentioned, however, differ from those of the ordinary series, in being of a sudden and not of a sustained character, and in having the action, which is commenced by a violent muscular contraction, continued by the impetus of the swing of the limb; and in neither movement can the long muscle, whose attachments are approximated, be considered as at all the principal muscle which is called into play.

Besides diffusing to distant joints the action of short muscles, a second advantage is gained by the long muscles in those instances in which the ligamentous function is combined with contraction, namely, that the contractile force is greater than it would otherwise be. For a less amount of shortening takes place than would be necessary to produce the desired effect on the joint which yields to the muscle, if the far extremity of the muscle were not dragged away from that joint; and it is allowed that the force of contraction of a muscle diminishes as the muscle shortens; that the force with which a muscle may be maintained in full contraction is less than that with which it is capable of maintaining the semi-contracted condition.

As a corollary to the proposition that the action of long muscles in those movements in which their length is unchanged is ligamentous, it may be laid down that in these circumstances they add nothing to the velocity of the movement, for they only convey from one joint to another the effects of the contraction of other muscles. Thus the rapidity with which the forearm is thrown forwards and withdrawn in the movements of boxing is quite unaided by the biceps and long head of the triceps, and produced altogether by the muscles which act on the shoulder and elbow-joints separately. In fact, the long muscles when acting ligamentously are diffusers and combiners, but are not producers of movement.

Various of the statements now made as to the mode of action of

long muscles find illustration in the following measurements of the hamstring muscles made on a dissected limb.

	Greatest possible separation of attachments after dividing the muscle.	Greatest stretch.	Length in extension of hip and knee.	Length in flexion of hip and knee.	Nearest approximation of attachments.	Length of fibre.
	inches.	inches.	inches.	inches.	inches.	inches.
Semitendinosus	$20\frac{3}{4}$	$18\frac{3}{4}$	$17\frac{1}{4}$	14	$12\frac{3}{8}$	$7\frac{1}{2}$
Semimembranosus	$17\frac{3}{4}$	$16\frac{1}{2}$	$14\frac{3}{4}$	$14\frac{1}{2}$	$13\frac{1}{4}$	$2\frac{1}{2}$
Biceps (exclusive of the short head)	19	$17\frac{1}{4}$	$15\frac{3}{4}$	$15\frac{1}{4}$	$13\frac{1}{2}$	$3\frac{1}{2}$

From this table it appears that none of the hamstring muscles are long enough to permit the combination of complete flexion of the hip-joint with complete extension of the knee.

It must be explained that in each muscle the different fibres were found to be of the same length, and that the measurement of fibre, in the case of the semitendinosus, has reference to the length of a fibre above or below the tendinous intersection, added to the length of that which was continuous with it on the other side of the intersection; and it must be borne in mind that in all three muscles the arrangement of the fibres is such that the contraction of one fibre represents the total possible contraction of the muscle. It will now be seen that the greatest approximation of attachments in the dissected limb was in each case a position incapable of being reached by the contraction of the muscular fibres, for the difference between greatest stretch and greatest approximation of attachments was in the semitendinosus $6\frac{3}{8}$th inches, which to be obtained by contraction would require each fibre to be shortened to $1\frac{1}{8}$th inches; while in the semimembranosus and biceps the differences between greatest stretch and greatest approximation of attachments were in the two muscles respectively $3\frac{1}{4}$ and $3\frac{3}{4}$ inches, lengths greater than the length of fibre in each case. But the rectus femoris had been removed, and that muscle limits the approximation of attachments of the hamstring muscles, as may be shown by throwing back the thigh and pressing the raised foot towards it with the hand, when pain will be felt in the rectus femoris, and the movement will be checked by it before reaching the amount of flexion of the knee which is possible when the hip is flexed.

It will be noticed that the semitendinosus contrasts very decidedly with the biceps and semimembranosus, in respect that while the short

fibres of these muscles undergo only a very slight contraction in the passage from extension to flexion of the limb, the much longer fibres of the semitendinosus are in these circumstances contracted to less than half their full length. From this it appears that the semimembranosus and biceps act chiefly in a ligamentous manner; and by the large number of their short fibres combining to maintain the required length of muscle they have great strength in their action, whether they combine with the vasti and crureus to erect the trunk upon the thigh in rising up, or convey the flexing action of the iliopsoas to the knee. The semitendinosus muscle, on the other hand, consisting of fibres few in number and with much more slender tendon than the biceps and semimembranosus, is much less fitted for bearing a great strain; but will move the knee quickly through a large area, and in this will act in company with the sartorius and gracilis.

In the bringing of these remarks to a close, another of the long muscles of the thigh, the rectus femoris, demands special notice on account of the remarkable arrangement of the superior tendon. Perhaps that arrangement, which is by no means peculiar to man, is not to be explained principally by physiological considerations; but it is at least interesting to observe that the advantage of having the fibres rather in medium than in full contraction, gained, as already said, in some long muscles by stretching of the fibres over a joint, is in this instance obtained by the peculiarity of the upper attachments. For if when the thigh is straight the anterior head of the rectus be cut, the muscle will be lengthened at least a quarter of an inch; or if when the thigh is flexed the posterior head be cut, the muscle will in like manner be lengthened. It is obvious therefore that had only one of the heads existed, there would have been a quarter of an inch more contraction of the muscle required, either in passing from the extended to the flexed or from the flexed to the extended position of the hip-joint. To gain that quarter of an inch of shortening without contraction of every fibre to that extent further than is its wont, would require the addition of probably half an inch of muscle; and that addition would require to be made to every fibre in order to be effective. The total addition of muscular action thus required would be considerable; and so also, therefore, is the saving of muscular action caused by the arrangement of the upper heads of origin.

ON THE RETINA OF AMPHIBIA AND REPTILES, by

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IN this paper I have sought to embody the results of a study of the amphibian and reptilian retina begun in 1862, and comprising now bufo vulgaris, rana temporaria, triton cristatus, the black and golden salamander of Europe, boa constrictor, natrix torquata, vipera communis, anguis fragilis, chameleon, Spanish gecho, iguana (tuberculata?), lacerta viridis, a larger blue-spotted lizard, testudo Graeca, emys or terrapene, and chelonia mydas. In all of these animals the retina shews the following layers in regular sequence from its outer to its inner surface[1]:

1. Bacillary layer = Layer of cones and rods = Jacob's membrane.
2. Outer-granule l.
3. Inter-granule l.
4. Inner-granule l.

(2–4) Collectively these form H. Müller's and Kölliker's Körnerschicht, with its three subdivisions, and Bowman's agglomerated granules.

5. Granular l....... = Kölliker's Lage grauer Hirnsubstanz. = H. Müller's granulöse Schicht, = Bowman's grey vesicular layer.
6. Ganglionic l......... = Müller's Nervenzellenschicht, = Bowman's caudate, nucleated vesicles.
7. Optic nerve l.

The plan which I have proposed to myself is to describe these layers seriatim, then to trace the continuity of the nervous and of the connective elements throughout the layers and interpret their physiological offices, and lastly to sketch the important structural modifications which mark the centre and the ora retinæ.

1. *Bacillary layer.*—In most of the animals comprehended in my study this layer contains both cones and rods, but in the chameleon, iguana, gecho, snake and viper, I found only one kind of bacillary element.

Pl. I. figs. 1—12. The cones and rods both consist of an outer and an inner segment, the former termed the shaft, the latter called the appendage or body. These parts are divided by a bright transverse line, at which the slightest force separates them. The constant occurrence

[1] In this paper *outer* always refers to the retinal surface towards the choroid, and *inner* to that towards the vitreous humour.

of the dividing line at the same height, its distinctness in perfectly fresh specimens, the evenness of the separated surfaces, the very facile separation of the segments, and their different refractive powers, speak for the normality of the segmentation and for its existence during life, and against its being merely a post mortem change.

The *shaft* (Pl. I. figs. 1—12 *a*), has sharp, hard outlines. It is a more conspicuous object than the appendage. Its profile figure is a slender rectangle (slightly tapering towards the outer end), but the actual shape is probably a cylinder or long prism. The outer end of isolated shafts is usually uneven from mutilation, but in perfect specimens it is a straight line. The inner end, which joins the appendage, is always limited by a sharp, straight line. A membranous sheath, and a contained homogeneous albuminous substance, granulated by coagulating agents, are the only natural parts recognizable. Ritter's 'axial fibre,' described from chromic acid preparations, is, I believe, the coarcted and drawn-out inner portion of the appendage, the outer portion of which is vesicularly dilated. The fibre always appears to me to pass without interruption into the contour of the vesicle, and never to lie inside this (Pl. I. figs. 3, 4). The true origin of the fibre is easily ascertained by tracing its gradual evolution through the numerous intermediate phases which occur between the stout, bulbous, and the slender-stalked vesicular metamorphoses of the appendage.

The *appendage* (Pl. I. figs. 1—12 *b*) is a pale, club-like, cylindrical or fusiform body. The outer end, that which joins the shaft, is abruptly truncated; while the inner end is either rounded, or it tapers, and it is prolonged into the outer-granule layer as a flattened ribbon or round fibre—the *primitive cone or rod-fibre,* collectively termed primitive bacillary fibres (Pl. I. figs. 8, 9 *e*).

A very constant difference is perceptible in the inner and outer parts of the appendage in perfectly fresh specimens examined instantly after decapitation of the animal, the former being less coarsely granular than the latter, which is either very finely granular or clear. This difference increases soon after death, and in chromic acid preparations the coarser granulation of the contents of the outer half is very obvious. Another difference is observable in the effect of carmine, which tinges the outer part lightly, or not at all, and deeply stains the inner.

The appendage, like the shaft, also consists of a membranous sheath and albuminous contents. In addition to this an outer-granule is always lodged in the inner end of the appendage whenever this latter is large enough to hold it (Pl. I. figs. 8, 12 *d*), and the outer end in the cones of some animals contains a bright globular bead, which always lies close to the line dividing the appendage and shaft (Pl. I.

figs. 2—12 *c*). Its colour is yellow or pale green in the toad, frog, triton, salamander, blindworm, and lizard; while the land and water tortoises and the turtle have also ruby beaded cones, the green beads lying in the smallest cones, the yellow in the intermediate, and the ruby in the largest. The occurrence of the cone-bead in the blindworm is interesting in connection with its other lacertian affinities. It is wanting in the common snake and viper.

Nothing is yet known of the chemistry of the colouring matter, or of the physiological meaning of these remarkable beads. I have found that rose-aniline imparts to the yellow and pale green beads the intense stain it gives the nucleus of the red blood corpuscle, and that iodine turns the ruby to mauve and the yellow to dark green. In the emys the red beads absorb the violet, indigo, blue, green, and part of the yellow rays of the spectrum to the *d* (soda) line, and transmit the remaining yellow, orange, and red rays. The yellow beads absorb the violet and other rays to about the *b* line of the spectrum, and transmit part of the green, and all the yellow, orange, and red rays. The green beads absorb the violet, indigo, and a small adjacent portion of the blue rays of the spectrum, and transmit all the rest. In short it appears that the beads absorb the rays belonging to the chemical, and transmit those belonging to the heat-domain of the spectrum[1].

Whatever other differences are held respecting the mode of visual perception, all physiologists have long agreed that the cones and rods are the sentient elements. This is concluded (1) from the absence of perception from the optic nerve-entrance, where there are no cones or rods; (2) from the unfitness of the other nervous tissues, by reason of their anatomical arrangement, to receive separate and distinct stimuli; (3) from the obvious fitness of the cones and rods by their serial arrangement in a single stratum, and their insulation, to receive distinct stimuli; (4) by the formation of a superficies by the outer ends of the shafts collectively, upon which correct images may be formed; and (5) by Purkinje's experiment, which demonstrates that the sentient elements lie at the outer surface of the retina.

Universal and decisive characters by which we may distinguish cones from rods are yet wanting, if indeed such will ever be discovered. Size, shape, and the cone-bead will not always serve us, for while the rods much exceed the cones in the toad, frog, triton, and salamander, their sizes differ little in the tortoise and turtle, and in the chameleon's central fovea the cones are as long and as slender as the most typical rods. Again, the bead, which is perfectly

[1] For the use of several spectroscopes and much valuable assistance in these observations, I am indebted to Mr Heisch.

decisive of cones when present, is altogether absent from many reptiles and from all mammalia, so that its absence does not count for anything.

The relations of the cones and rods to the choroid differ from those which obtain in the human retina, where the outer ends of the shafts simply stand on the pigment epithelium. In amphibia and reptiles the outer ends of the shafts similarly rest on the choroidal epithelium, but processes of pigment are prolonged from this inwards between the shafts, sheathing them and separating each one from its neighbour. The pigment is granular, and the grains lie in linear series, perpendicular to the choroidal surface, embedded in a soft interstitial tissue which occupies the spaces between and around the cone shafts.

My observations respecting the relations of the cones and rods to the membrana limitans externa, and the nature of this membrane, agree with those of Schultze. It is a fenestrated, glassy membrane, and the cone and rod-appendages perforate it, sitting in its apertures, as Schultze says, like eggs in an egg-board, and prolonging themselves at its inner surface into the next layer in the form of primitive bacillary fibres.

2. *Outer-granule layer.*—Perfectly fresh outer-granules, examined in vitreous humour, are large, circular, or roundly-oval nuclei, occasionally containing a nucleolus (Pl. II. figs. 1—4 *a*). In chromic acid preparations, besides these circular outer-granules, elliptical (myrtle-leaf) ones are not unfrequent, particularly in the salamander and frog (Pl. II. figs. 1, 2 *b*), and these have been distinguished by the name cone-granules from the belief that they are always associated with cones and never with rods. The myrtle-leaf outer-granules belong, however, indifferently to cones and rods, and are not the granules (so called) simply and solely, but they are granules sheathed in a production of the bacillary appendage which shrinks under the influence of the chromic acid (used to harden the retina preparatory to making the sections), and alters the shape of the granule which it encloses.

The number of the outer-granules equals that of the cones and rods, since each of these has one of the granules associated with it in one of two ways: either the bacillary appendage, when its size allows, includes the granule in the manner already described, or when too slender to include it communicates with it by the intervention of the primitive bacillary fibre. The closeness of this relation justifies us in regarding the outer-granules as the nuclei of the bacillary appendages.

The layer is traversed obliquely from its outer towards its inner surface, and in a direction from the centre of the retina

towards the ora by the primitive cone and rod-fibres, the obliquity of these fibres decreasing as their distance from the retinal centre increases; and it is traversed perpendicularly to its surfaces by another set of fibres which course outwards in a direction radial from the centre of the globe towards the inner surface of the membrana limitans externa, where they lose themselves. These are the terminations of the connective-tissue fibres, named after their discoverer, H. Müller, and the former set are nervous.

This different arrangement of the two systems of fibres was first discovered by Müller in the chameleon. I have observed it in all the animals included in this paper, but plainest in the lizards (Pl. III. fig. 1). Since it is repeated in the following layers it is of the greatest value, because it enables us to ascertain the anatomical nature of a particular fibre from its direction, and to deduce the nature of the nuclei and cells in the granule and inter-granule layers from their relations to the fibres.

3. *Inter-granule layer.*—This consists of a thin stratum of connective-tissue bounding the outer surface of the inner-granule layer (Pl. IV. fig. 2 *f*), and of a nervous plexus lying between this stratum and the outer-granule layer (Pl. IV. fig. 2 *g*).

The nervous plexus arises out of the union of the primitive bacillary fibres at the inner surface of the outer-granule layer. In the chameleon, iguana, and gecho, it is remarkably conspicuous at the centre of the retina, where it forms a very thick band, which thins out and becomes less apparent towards the ora. In chelonians the arrangement of the plexus is essentially the same, though less evident.

The general direction of the bundles of the plexus coincides with that of the primitive fibres in the outer-granule layer, and the bundles interchange in such a way that the fibres are brought from the outer towards the inner surface of the plexus. Here the bundles are again resolved into delicate fibres, which pass through the connective-tissue stratum into the inner-granule layer.

4. *Inner-granule layer* (Pl. II. fig. 6). Here, as has been mentioned, we find the same two systems of fibres, one obliquely radial from the outer towards the inner surface of the layer, and from the centre towards the ora of the retina; the other having a direction vertical to the surfaces of the layer, and radial from the centre of the globe: the first system is nervous, the second connective-tissue.

The oblique fibres have two sets of cells associated with them. 1. Small, oval, or bipolar nuclei, which lie in the finer fibres. These are more numerous, and occur everywhere throughout the layer. 2. Larger, nucleated, branched cells, receiving on the one side stout fibres, resulting from the union of the finer ones just mentioned, and

on the other side detaching fibres, which obliquely pass through the granular layer, and join the outer branches of the cells of the ganglionic layer. These larger inner-granules are less numerous than the smaller, and occur mostly near the inner surface of the layer.

The vertically radial connective-tissue fibres have long fusiform bodies in close relation with them. The first impression conveyed to the mind is that they are nodal thickenings; but more careful inspection shews that they are independent structures, perhaps homologous with connective-tissue corpuscles, closely clinging to the radial fibres by finely areolated branches.

5. *Granular layer* (Pl. IV. fig. 1 *g*). This keeps a more uniform thickness throughout the retina, and declines more gradually towards the ora than the other layers. At the thin edges of good sections the tissue, as Schultze pointed out, may be seen with a high magnifying power to be finely areolated. Its derivation, in great part from the radial connective fibres which run vertically through it, shews that it is a connective-tissue. The granular appearance is produced by the fineness of the net, and by the innumerable ends of the extremely delicate fibres divided in the section.

Dark bands, in which a longitudinal fibrillation is sometimes apparent, are very constantly seen in lizards, parallel with the surfaces of the layer.

The oblique nervous fibres mentioned in the inner-granule layer run through this layer also obliquely on their way to the ganglionic layer.

6. *Ganglionic layer.*—The constituents of this layer are (1) large, strongly outlined, circular nuclei, and (2) larger, branched, nucleated cells having a faint contour, and a pale, finely granulated texture (Pl. II. fig. 5). They lie between the vertically radial connective-tissue fibres.

The free nuclei so closely resemble the nuclei of the branched cells, and so frequently have fragments of tissue adhering to them which is not optically distinguishable from the tissue of the cells, that it seems probable they have escaped from cells and that all the perfect cells are nucleated and branched.

The connection of the branched cells with the nervous fibres coming through the granular layer from the inner-granule layer was mentioned in the description of this last layer. On the other side the cells detach branches which join the optic nerve fibres.

7. *Optic-nerve layer.*—The optic nerve pierces the eyeball below the axis, at its temporal side. In lizards the spot at which the nerve appears at the inner surface is marked by a well-developed conical or sword-like pecten. The boa also has a minute globular pecten (Pl. III. fig. 3), and the common viper a still more rudimentary one,

but the common snake, blind-worm, tortoise, and turtle, have none. The base of the pecten is continuous with the choroid. It is formed by a vascular plexus with a little pigmented interstitial connective-tissue; its surface is even and not plaited as in birds, and it is overlaid by a thin stratum of pigment, and by a hyaloid membrane channelled by the blood-vessels, which are distributed between the outer surface of the vitreous humour and the retina.

The bundles of nerve fibres run through the base of the pecten and radiate towards the ora in a plexus with long meshes, in such a manner that those bundles of fibres only which are distributed to the retinal centre pass directly towards this from the pecten, while those bundles proceeding to parts beyond the centre, at its nasal side, arch above and below this latter in increasingly open curves. The bundles are separated from the membrana limitans interna by a thin stratum of tissue identical with that of the granular layer.

The fibres resemble axis-cylinders. Fresh ones are perfectly transparent. In chelonia their diameter is less uniform than in the lizards and snakes, and they are more varicose than in these latter animals and in the frog and salamander. The connection of the nerve-fibres and ganglion-cells has been already mentioned.

We now come to the membrana limitans interna, a structureless membrane which bounds, as its name conveys, the inner surface of the retina. The outer surface of the membrane gives origin to Müller's radial fibres, which arise from it by winged, decurrent expansions (Pl. IV. fig. 1 *f*); and the inner surface is so closely applied to the hyaloid capsule which encloses the vitreous humour that it cannot always be artificially separated from it.

I repeat that there are not any blood-vessels in the retina in these animals. Their absence is compensated by the close relation of the bacillary layer to the vascular choroid, and by the net of the blood-vessels in the hyaloid capsule (Pl. III. fig. 4 *e*).

My readers will now be able to follow me as I trace the continuity of the nervous and of the connective-tissues through the different layers, in doing which the different directions of the fibres prove of the utmost service.

Beginning with the nervous tissues, at the outer surface of the retina (that which is furthest from incident light), we find the sentient cones and rods, each one of which, by means of its appendage, or through the intervention of its primitive fibre, is associated with an outer-granule so intimately that we may regard this latter as the nucleus of the appendage, which we may consider a specially modified cell.

The primitive cone and rod-fibres continued from the appendages traverse obliquely the outer-granule layer, and at its inner-surface

form a plexus, which constitutes a large part of the inter-granule layer. The bundles of this plexus keep the same general direction as that of the primitive fibres, and at its inner surface break up again into fine (primitive?) fibres which run through the connective-tissue stratum of the inter-granule layer into the inner-granule layer. Here they take up the lesser inner-granules, and form a second plexus with long obliquely directed meshes. Towards the inner surface of the layer the bundles grow stouter by the union of the smaller fibres, and end in the large branched cells resembling ganglion-cells, which in turn give off other branches that run obliquely through the granular layer to the ganglionic layer, and join here the outer branches of its cells, other branches of which become continuous with the optic nerve-fibres.

Our knowledge is at present too imperfect to allow us to fix with certainty the physiological offices of all the elementary nervous tissues; for while the indications respecting some are so strong as to amount as nearly to demonstration as the case permits, with regard to others they are so weak as to be merely suggestive. The cones and rods fall in the first class; all agree that they are the sentient elements; but if we go beyond this and try to fix the meaning of each of the parts composing them, we stumble at once on great difficulties.

The high refracting power, the straight sides, and the insulation of the shafts by black pigment, suggest a physical, optical office; while the absence of these very qualities, and the presence of a nucleus (outer-granule), hint that the appendage performs a vital role. May it be that at the junction of shaft and appendage light is converted (if I may so express it) into nerve force? The absorption of the chemical rays of the spectrum by the cone-beads which lie here favours this conjecture.

If the outer-granule is rightly regarded as the nucleus of the appendage, we presume its office is the maintenance of the integrity of this latter as a living organ.

The system of oblique fibres, from its structural continuity with known nervous tissues (e.g. the cones and rods, and the ganglion-cells) must be also nervous, and its function internuncial.

It is not certain whether we ought to regard the smaller inner-granules as the nuclei of a particular segment of the oblique-fibre system, or as bipolar ganglion-cells; but the close similarity of the larger inner-granules to ganglion-cells, their relations to the stouter oblique fibres, and their connection with the cells of the ganglionic layer (by fibres running through the granular layer) indicate these inner-granules to be ganglion-cells. Since each primitive bacillary fibre represents a cone or rod, and the stouter fibres going to the

larger inner-granules are composed of several of the finer fibres, it results that each of these granules corresponds with several bacillary elements, and its inner branches serve to convey the nervous currents received from them through the oblique fibres to the cells of the ganglionic layers.

Each ganglion-cell probably communicates with more than one larger inner-granule, and through these with as many groups of cones and rods; and these relations hint that the cones and rods may be disposed in physiological groups, each of which is controlled by a ganglion-cell.

I now proceed to review the connective-tissues in the same manner as the nervous. They consist of (1) the membrana limitans interna, and memb. limit. ext.; (2) a system of fibres running vertically between these membranes, named after Müller; (3) finely areolated interstitial tissue. The limiting membranes and their relations to the other tissues and the granular layer which properly belongs to this section, have, for convenience' sake, been already described; and the origin of Müller's fibres from the outer surface of the limitans interna was noticed, so that it only remains to trace the general course of these fibres. They pass from the membrana limitans interna outwards, vertically through all the layers, and branching repeatedly, and becoming ultimately very fine, they end at the inner surface of the membrana limitans externa. They evidently form a frame, the office of which is to bind the layers together. In their outward course they first pass through the meshes of the optic nerve plexus, and through the ganglionic layers, where, in vertical sections tangental to the optic nerve entrance, they resemble stout pillars with arcade-like interspaces which transmit the nerve-fibres, and lodge the ganglion-cells. The arches are constructed of branches which the stout trunk-fibres detach before they enter the granular layer. Pursuing their outward course through this layer, the fibres give off within it numerous fine branches which, repeatedly subdividing and interlacing, contribute to the areolated tissue of the layer. I have found this even plainer in the turtle than in the frog, in which Schultze first described it. The designation "grey nervous layer," and others implying a nervous character, are evidently founded on error and should be discontinued. The further distribution of the fibres differs at the centre and at the periphery of the retina. In the former place most of the fibres springing from the inner limiting membrane end, in the turtle and tortoises, at the outer surface of the granular layer, where another set of vertically radial fibres (which

we may distinguish as the *outer* radial fibres) arises, principally out of the areolated tissue of this layer, and to a less extent directly from the fine terminal branches of the inner radial fibres.

These outer vertically radial fibres form a second series of arches, and forking acutely, in the same way as the inner fibres, pass through the outer-granule layer, to end at the outer limiting membrane. In lizards these outer vertically radial fibres arise out of the thin stratum of connective-tissue mentioned in the description of the inter-granule layer. Towards the periphery of the retina the fibres from the membrana limitans interna traverse all the layers and reach the limitans externa; and here the outer fibres, as a distinct set, are absent.

The interstitial tissue, which is essentially identical in structure with the granular layer, is continuous with and principally derived from the repeated subdivision of the finer branches of the vertically radial fibres. It fills the minute spaces between the elementary nervous tissues, fixing them in their several layers and preserving their stability. It possibly also insulates them, maintains the distinctness of each nervous chain between the cones and rods and ganglion-cells, and prevents the lateral discharge of the nervous current.

The Fovea Centralis, and the Ora Retinæ.—Two parts of the retina differ so much in their structure from the rest as to require separate notice: these are the centre and the periphery or ora.

The first notice of the existence of the fovea centralis in reptiles which I can find is by Knox, in the *Memoirs of the Wernerian Society,* 1823, where he describes very accurately the macula and foramen centrale in the chameleon, and says he had also seen it in lacerta superciliosa, l. scutata, l. calotes, and l. striata. There was recently in the Anatomical Museum at Frankfort a preparation of the chameleon's eye with an inscription in Soemmering's handwriting describing the foramen, which proves it to have been known to this great anatomist; and there are also in the Museum of the Royal College of Surgeons two old preparations of the chameleon's eye (undated, Hunterian?), which time has spoiled, but which the catalogue says are intended to display the foramen. These preparations and Knox's memoir were overlooked by later investigators, and till very recently it was commonly taught that the macula and central fovea were peculiarities of the human retina and of that of some apes. In 1862 this error was for ever set aside by H. Müller's remarkable memoir on the chameleon's eye[1], in which he described with great exactness the macula and fovea, and the two sets of vertically and obliquely radial fibres here so conspicuously distinct.

[1] *Wurzb. Naturwis. Ztschr.* 1862.

The large number of chameleons brought to London in 1864 gave me greater advantages than Müller, whose only material consisted of eyes which had been long in chromic acid solutions, and it enabled me, while confirming him in every essential point, to make out some particulars which he had been obliged to leave undetermined[1]. Since then I have found the oblique nervous fibres, and a point corresponding to the human fovea centralis, in all the animals included in this paper. In the chameleon's retina, where the fovea is more developed than in snakes and chelonia, it is a minute, deep, circular pit in the inner surface of the retina, at the posterior pole of the eyeball. (Pl. VIII.) The centre (bottom) of the pit is a minute brown dot encircled by a lighter ring corresponding to the sides, and this, in turn, is surrounded by a colourless belt which merges gradually into the surrounding parts. The surface slopes in a rapid and uniform curve from the border to the bottom of the pit, and declines slowly from the border towards the ora retinæ, so that the foveal border is the most elevated, and the foveal centre the most depressed part of the macula.

The pit is produced by the obliquely radial deflection on all sides of the primitive cone-fibres and their prolongations from a point in the inner surface of the bacillary layer, and by the peripheral displacement of the outer and inner granules and the ganglion-cells connected with the central cones from this point.

In vertical sections laid accurately through the centre of the fovea, the optic nerve, granular, and inner-granule layers, the plexus of cone-fibres which forms the principal part of the inter-granule layer, and the inner limit of the outer-granule layer, are seen to bend outwards at the foveal border and, rapidly thinning out, to converge towards the bottom (centre) of the fovea, where they cease; only the cones, with their diverging primitive fibres embedded in a very thin stratum of finely areolated interstitial connective-tissue, occurring at this point. Reviewing the layers at the macula in their order from the outer to the inner surface of the retina, we find first the bacillary which contains cones only. These are very long, and so exceedingly slender that a superficial unit here contains more of them than at any other part, which is evidently connected with the greater visual acuity of the retinal centre, since the sensitiveness of a surface is proportioned to the number of distinct percipient elements it contains. The cones decline slightly in length, and grow slightly stouter from the foveal centre to the periphery of the macula; and hence to the ora, rapidly for a short space, and then gradually for the remaining distance, they become much broader, and shorter.

[1] Cf. a paper in the *Phil. Trans.* of the current year.

The extreme slenderness of the central cones does not allow the appendages to include their outer-granules at this part, and these latter being displaced towards the foveal border, the primitive cone-fibres passing to them from the appendages must necessarily have a correspondingly radial deflection. The result of this displacement of the outer-granules belonging to the central cones is a very rapid growth of the outer-granule layer in a peripheral direction from the foveal centre. It reaches its maximum at the foveal border, where the thickness of the layer is very remarkable, then declines slowly for about $\frac{3}{4}'''$, and then thins out rather suddenly towards the ora. Succeeding the outer-granule layer, the remarkable plexus of the inter-granule layer formed by the cone-fibres begins in the angle between the outer and inner-granule layers near the foveal centre. Rapidly growing, it reaches its maximum thickness just beyond that of the inter-granule layer. The bundles of the plexus are obliquely deflected, the innermost least so.

The inner-granule layer closely approaches the outer at the bottom of the fovea, in consequence of the extreme thinness here of the plexus just described. At this point it is extremely thin, but, like the preceding layers, it quickly grows broader, and it attains its maximum a little way beyond that of the plexus.

The granular layer, and the granular stratum which elsewhere separates the optic nerve layer from the membrana limitans interna, blend at the foveal centre with the interstitial connective-tissue in which the central primitive cone-fibres are embedded. From this point the granular layer increases in breadth, reaching its maximum at the foveal border, and preserving this nearly to the ora retinæ. The ganglion-cells around the foveal centre lie in a single interrupted series which halfway between the centre and border of the fovea becomes a continuous band of two or three rows, while at the border the cells lie four or five deep. The layer of optic nerve fibres is not absent, as some have thought, but only very attenuated. It is possible to trace fibres nearly to the foveal centre.

The connective-tissue fibres traverse the layers vertically as they do at other places, but, owing to the curve of the inner surface of the retina at the fovea, their direction is not radial from the centre of the eyeball.

The anterior margin, or ora retinæ, is not serrated as in man, but even. All the nervous elements cease here, but the connective-tissues, in a modified form, are prolonged into the ciliary region.

The cones and rods, which for some distance from the ora have declined in length and size, suddenly altogether cease, and the outer and inner-granule layers thin out and terminate. Where the bacillary elements disappear the processes of black pigment prolonged

from the choroid in between them also cease; while the membrana limitans externa, approaching the choroidal elastic lamina very closely, yet separated from it by the stratum of pigment epithelium, runs forward upon the ciliary body. The attenuation of the layers towards the ora brings the inner limiting membrane closer to the outer, like which it is also produced beyond the ora. The prolongations of these two membranes in the ciliary region are separated by a very distinct stratum, which in lizards and in the emys is fibrillated vertically to its surfaces, but in the turtle it has a more reticulated structure.

A few horizontal fibres run a little way into this stratum from the granular layer at the ora, but its vertical fibres are continuous with the radial connective-tissue fibres which in the ciliary region lose their retinal characters, and become very short and relatively broad, especially their inner ends. They are often very regularly nucleated. At the tips of the ciliary processes the two membranes coalesce and form a single one, from the inner surface of which the stiff fibres of the ligamentum suspensorium lentis arise.

NOTES ON AMYLOLYTIC FERMENTS, by M. FOSTER, jun., B.A., M.D., F.C.S.

A STATEMENT is often found in text books, that all decomposing animal substances have the power of converting starch into sugar with greater or less rapidity, and that this power is connected with the processes of decomposition. As far as my experience goes, this is entirely erroneous. There are numerous fluids in various animals which possess this power; but they manifest it as well when fresh, i.e. when employed within a few minutes after removal from the living body, as during any stage of the subsequent decomposition. On the other hand, fluids which do not possess this power when fresh, never acquire it by any ordinary process of decomposition. Thus human blister-fluid, or the serum of sheep's blood, is powerless upon starch when fresh, and equally powerless in all stages of decomposition. The substance, called by some *vitellin*, which is readily obtained from the yolk of hens' eggs in a state of great purity without the use of any possibly injurious re-agents, is powerless on starch both when fresh (either as a precipitate or in a saline solution) and in all stages of decomposition. Bernard states that when fibrin is washed and placed in water, the water in a few days acquires the power of converting starch into sugar, and he supposes decomposition to have given rise to the power. But fibrin of certain animals, even when quite fresh, will act on starch; and in certain animals will not act either when fresh or when allowed to remain for any length of time in water. Bernard even goes so far as to attribute the amylolytic power of saliva and pancreatic juice to a decomposition of those fluids, regarding them as peculiarly prone to rapid decomposition. But in this case, one must extend somewhat the ordinary meaning of the word decomposition—for sub-maxillary saliva, allowed to drop from the duct, through a fine tube, into boiled starch, brings about the change into sugar quite as rapidly as when it has been collected and allowed to stand for some time.

Another and allied statement is, that the agent of the change, the amylolytic ferment[1] (if it is admissible to use that term) is an albuminoid body—some product of albuminoid changes. Thus the various protein bodies found in saliva have been charged with this function, and a form of potash-albuminate or casein, occurring in pancreatic juice, has been said to be the active principle of that fluid, and hence has been called *pancreatine*. On this it may be observed,

[1] I hope the very great convenience of a new term, often amounting to the saving of a sentence, may be considered a sufficient excuse for its introduction.

that to none of the ordinary forms of albumin by themselves does this power belong. Thus if pancreatic juice, or infusion of pancreas be saturated with sulphate of magnesium and filtered, the whole of the so-called pancreatine is retained on the filter. Nevertheless, the filtrate will be found to have lost a fraction only of its amylolytic powers. Again, in saliva, the power does not reside in the mucus or in the globulin; for, freed from either or both of these, the fluid is as amylolytic as ever. Moreover, in any fluid the power over starch is by no means commensurate with the quantity of proteids[1] present; if there is any ratio at all it is an inverse one.

If the ferment be a proteid at all, it must be some particular distinct form of proteid. That it is a proteid is suggested by its occurrence in proteic fluids only, and by its losing its powers at about the temperature of the coagulation of various forms of albumin. To prove that it is not a proteid, one ought to be able to prepare a fluid possessing strong amylolytic powers and yet giving none even of the most delicate proteic reactions (such as Millon's and the xanthoproteic). It is very easy to obtain a strongly amylolytic fluid containing traces only of albumin, e. g. by precipitating saliva with acetic acid and ferrocyanide of potassium, filtering and neutralizing. But so long as there remains enough albumin to give Millon's reaction, one is not justified in denying a proteic nature to a body whose powers are, so to speak, out of all proportion to its bulk. Cohnheim, following Brücke's pepsin method, has stated that when a precipitate of calcic phosphate is produced in saliva, both the ferment and the proteids are carried down, and that when the precipitate is separated and agitated in distilled water the ferment is given up to the water, but not the albumin; hence by decantation and filtration a strongly amylolytic fluid with no proteic reactions is obtained. Upon evaporation, however, or by precipitation with alcohol, a nitrogenous body is obtained. (I must confess to frequent failures when working by Cohnheim's method.) Again, if urine is mixed with three or four times its bulk of alcohol, the deposit filtered off, washed with alcohol, extracted with cold water and filtered, the filtrate forms an amylolytic fluid often giving no visible proteic reaction. Upon concentration by evaporation, however, the reaction becomes distinct. The natural deposits of urates (with or without previous washing with alcohol) when agitated in distilled water, give to the water distinct amylolytic powers; hence an amylolytic fluid without proteic reactions may thus be obtained. Further, Cohnheim has shewn that the amylolytic ferment is not acted upon by gastric juice.

[1] A term suggested by Mr Huxley. Its use of course implies no adhesion to the "protein theory."

The influence of circumstances on the action of the amylolytic ferment.

The time required for the conversion of a given quantity of starch is proportional to the amount of ferment present; this comes out so strongly in all experiments, that the time required for the operation may be taken as a measure of the amount of ferment.

The more dilute the solution of starch employed, the more rapidly does a given amount of ferment work. Hence, in estimating the activity of a fluid, it is requisite to employ not only a given weight of starch, but also a given quantity of water.

The presence of neutral salts (chlorides and sulphates of sodium, potassium, &c.), even to saturation of the solution, has no appreciable effect. Here is another argument against the proteic nature of the ferment. Metallic salts in general arrest the action. Ferrocyanide of potassium is innocuous; so likewise iodide of potassium.

The effect of the addition of acids and alkalis depends upon the degree of concentration. Taking a neutral or faintly alkaline reaction as the condition of greatest intensity, the effect of an increase in either direction, is, first to delay the action, next to suspend it, the power returning upon neutralisation, lastly to destroy it altogether. Thus to 2cc. of filtered saliva (of known activity) one drop of liq. pot. was added; the mixture became inactive. Upon neutralisation, the activity returned, without having suffered any marked loss. To 5cc. of saliva, 5cc. of liq. pot. were added; the activity was entirely and permanently lost. This effect of either acid or alkali is largely dependent on time and temperature.

In the conversion of starch into sugar, is there any consumption of ferment?

To determine this question, I made the following experiment. Of a specimen of diluted and filtered saliva 10cc. were added to 10 grains of starch boiled in 90cc. of water (A), and another 10cc. to 90cc. of water (B); both were exposed to 35°C in vessels of the same shape and size. As soon as all the starch had disappeared from A, 10cc. of it were added to 10 grains of starch boiled in 90cc. of water (C). At the same time 10cc. of B (together with 10cc. of A well boiled in order to destroy the ferment[1]) were added to 10 grains of starch boiled in 80cc. of water (C_1), and also 10cc. of B to 90cc. of water (B_1). All three were exposed to 35° in vessels of the same shape and size. The appearance of sugar and disappearance of starch in C and C_1 were noted. When the starch was wholly gone from C, a similar procedure was adopted, giving rise to solutions D, D_1,

[1] This was done to counterbalance the presence of the sugar in C; sugar, according to Cohnheim, being a hindrance to the action of the ferment.

and B_2, and the appearance of sugar and disappearance of starch in D and D_1 noted. And then the procedure was repeated several times. I argued that if there were any consumption of the ferment, then the series C, D, E, &c., which contained previously used ferment, would be slower in their changes than the series C_1, D_1, E_1, &c., which contained unused ferment, all other conditions being apparently alike in both series. I found that the rapidity of change was equal in both series; only, in the last members, where many hours were required for the conversion of the starch, the result was slightly in favour, not of the latter, but of the former series. This slight, very slight increase, I should be inclined to connect with the so-called spontaneous conversion of boiled starch. I have reasons for believing that when a solution of recently boiled starch is mixed with a solution of boiled starch previously converted into sugar by mere lengthened exposure to air, the conversion into sugar is somewhat hastened.

Thinking that in the above case the amount of starch was too small to have a marked consuming effect on the ferment, I repeated the experiments, using 1 oz. of starch in 200cc. of water, instead of 10 grains, but the result was exactly the same. The ferment, therefore, is not consumed during its action, unless we suppose that, commensurate with destruction, there is a generation of ferment; an hypothesis for which there is not the slightest evidence. The fact that a given quantity of amylolytic fluid will, *sooner or later*, convert any quantity of starch into sugar is presumptive evidence that, in the action which takes place, the ferment itself is unchanged.

Schönbein has suggested that the catalytic effect of saliva on starch is connected with its catalytic power over peroxide of hydrogen, &c. But in truth there is no relation whatever between these two powers, as the following experiment among others will shew. To a given quantity of water containing peroxide of hydrogen was added a small quantity of diluted and filtered saliva of known activity. Watched for several hours, the bubbles of gas given off were hardly noticeable. It was then divided into two parts. To one a few drops of blood were added; a brisk escape of bubbles took place. The other was made to act upon starch; the ferment in it had apparently lost none of its activity. To a like quantity of the same peroxide of hydrogen solution a small quantity of sheep's blood was added. A brisk escape of bubbles took place. When they ceased to be given off, more blood was added; but no further bubbles were seen, shewing that the peroxide was exhausted. The mixture had no effect whatever on starch.

On the distribution of the amylolytic ferment.

Besides the salivary and pancreatic bodies, and their secretions, there

are also other fluids and tissues containing ferment[1]. Thus in certain animals the liver and the blood are amylolytic. It has been supposed by many that in the liver the ferment is seated in the blood and not in the hepatic tissue; but, I venture to think, erroneously. Liver, after the blood has all been washed out by a stream of water, is amylolytic. This however is not a conclusive argument, since the ferment may, in the process of injection, have been carried through the coats of the blood-vessels into the tissue proper. The following experiment is free from such objections. A portion of liver was bruised in a mortar, treated with cold water and filtered. A portion of the blood of the same animal (a rabbit) was diluted until it and the liver infusion were of such a colour as to justify the inference that both contained the same amount of haemoglobin and therefore of blood. On trying both with starch, the liver infusion was found to be by far the most strongly amylolytic. Had the ferment of the liver belonged to its blood only, the two solutions would naturally have been equal in power. Portal blood, moreover, in the rabbit, at least in one case in which I tried it, was less amylolytic than the blood of the inferior vena cava. Grohe has observed that chyle is amylolytic, and I have always found pericardial fluid to be strongly so. I have also obtained decided action with pleural and peritoneal fluid. Lymphatic glands however seem inert. Cohnheim and Béchamp have shewn the existence of amylolytic ferment in perfectly fresh filtered urine. It is sufficient to neutralize the urine in order to demonstrate this effect; but the ferment may be approximately isolated by the calcic phosphate process, or by treating the urine with four or five times its bulk of spirit, collecting, washing with alcohol, and drying at a low temperature the deposit, then treating with cold water and filtering. The filtrate is strongly amylolytic.

The origin of this urinary ferment is a matter not without interest. Béchamp thinks that the kidneys produce the ferment, but brings forward no facts to support his views. An infusion of kidney, moreover, is but very slightly amylolytic. An infusion of urinary bladder is strongly amylolytic, and it might be supposed that the urine during its stay in that organ absorbed ferment; but the amylolytic power of urine does not vary with the length of time the water is held before being passed.

The following facts seem to indicate that the urine is merely a channel for the excretion of a certain amount of the ferment contained in the blood. The amount of ferment in urine is increased after meals; that is to say, one hour's urine passed after food has been taken acts more rapidly on a given quantity of starch than one

[1] Whether the ferment in all these parts is identical can be determined only when we are able to recognize the ferment by some other features than its amylolytic powers.

hour's urine passed while the stomach is empty, care being taken of course to avoid the influence of changes of reaction. In man both blood and urine are amylolytic; in the pig and in the rabbit the case is the same. In the sheep however the urine has an exceedingly feeble amylolytic action; in the sheep too the action of the blood (be it serum or clot, or both) is almost *nil*. Starch may be exposed at 35°C with sheep's blood for many hours and yet not more than a small fraction of it will be converted into sugar. The contrast between the pig and the sheep in this respect is very marked. While throughout the pig's body the ferment is not only widespread but exceedingly active, in the sheep's body, on the contrary, its presence seems to be practically limited to the pancreas and liver. This distinction, moreover, cannot be traced to any difference of food or circumstances of life or mode of death. In the human body the amount of ferment in the urine when a vegetable diet is used seems to be about the same as when under an animal diet. At least three days' trial of each made no difference.

Since pig's blood, when shed, is strongly amylolytic, while sheep's blood is not, it is evident that in the living blood-current of the pig there must be either a ferment actually existing as such, or a particular substance which is potentially a ferment, inasmuch as it becomes a ferment immediately that the vital equilibrium of the blood is destroyed by removal from the blood-vessels. The parallel absence and presence of ferment in the blood and urine of the pig and the sheep, while they suggest the blood as the source of the urinary ferment, also indicate that the condition of the ferment in the blood is actual and not merely potential.

Schiff (*Robin's Journal,* III. No. 4) argues that the blood, so long as it circulates through the living blood-vessels, contains no ferment, but that, directly stagnation occurs, a ferment is developed. He is also of opinion that the ferment which converts the glycogen of the liver into sugar is provided by the blood. I have already shewn reasons for thinking that the hepatic ferment is contained or concentrated at least, even if not generated, in the hepatic tissues, and is not a gift of the portal blood, nor of that of the hepatic artery. The inviolability of starch-granulose injected into the blood-current is quite intelligible on the hypothesis of a "vital" inhibitory influence similar to that which prevents the coagulation of the blood &c.; and the appearance of sugar in the urines, and the increase of sugar in the livers, of animals whose limbs have been ligatured, may be perhaps attributed to the other effects of the ligature rather than to the stagnation of the blood. The mere application of a tourniquet to the human arm for half an hour will produce modifications of the urine (which I have not yet studied) before the loosing takes place,

and therefore before the blood, altered as supposed by stagnation, can have had opportunity to work upon the organism.

That the disease *diabetes* is due not to any excess but rather to some modified action of ferment, seems to be indicated by the fact that in six cases examined by me, comprising most of the chief types of that malady, the amount of ferment passed in the urine per diem in no way exceeded that passed by persons in health. The blood of a diabetic person moreover was found to be not more amylolytic than that of one in health, which it ought to have been, had the specimen contained, according to Schiff's theory, besides the ferment due to its own decomposition, a quantity which it, when shed, was bearing from other parts of the economy.

ON THE NATURE OF RIGOR MORTIS, *by* R. Norris, M.D.

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The following paper on the nature of rigor mortis was read at the Birmingham Meeting of the British Association, Sept. 1865, and was the subject of a grant. The consideration thus accorded led to a more extended series of investigations, which were laid before the meeting at Nottingham in August last, in the form of a paper entitled "Researches on Muscular Irritability, and the Relations which exist between Muscle, Nerve, and Blood." This latter contribution will, in all probability, appear in the succeeding number of this Journal.

This paper has for its object the refutation of the commonly received opinion of physiologists in regard to the nature of rigor mortis, or cadaveric rigidity, viz. that it is the result of muscular contraction.

The plan I propose to adopt is to support by experimental proof the three following propositions:

Prop. I.

If in any animal there exists, at any given period, a tendency to universal muscular contraction there will necessarily be a redisposition of the limbs in favour of the most powerful series of muscles, be they flexors or extensors.

Prop. II.

Contraction and shortening, as applied to muscles, are synonymous terms. If any muscle, having its attachments perfect, becomes shorter, in however slight a degree, it will, if *unopposed,* involve a relative redisposition of the osseous structures to which it is attached; if in a limb, the position of the limb will be altered.

Prop. III.

Contraction and the presence of irritability being inseparable associations, it follows that if, in some cases, irritability is absent for a long period prior to the supervention of rigor mortis, the latter cannot be regarded as a contractor.

In respect to the first proposition there are many ways by which the entire muscular systems of some animals may be thrown into convulsive contraction, either permanent or intermitting in its character. The frog is an animal well adapted by its anatomical con-

struction to exhibit extremes in muscular contortion, inasmuch as the extensor muscles highly preponderate in the hind extremities—an arrangement adapted to the acts of leaping and swimming. Now if by any means the entire muscular system of this creature is made to tend to contract, we get the hind limbs rigidly extended. If, e.g. we place a frog under the influence of strychnia, it is not simply the extensor muscles which are tending to convulsion during the spasm. The extension of the limbs in this case is simply the result of the preponderance of extensor power in the hind extremities; for if, before exciting the nervous system with strychnia, we divide the extensor tendons, the corresponding flexor muscles will be thrown into convulsive spasm and, as a consequence, the limbs will be powerfully flexed. Idio-muscular contractions of a permanent character have been long known to be producible in frogs by extremes of temperature as high as 130° or as low as 25° Fahr.

I have myself discovered that many vapours, among which chloroform, ether, and bisulphuret of carbon stand out most prominently, possess the property of exciting permanent contractions in the muscles of the frog, of as powerful a character as the most extreme neuro-muscular action of strychnia. As in thermal tetanus, these latter phenomena depend for their existence upon an action directly exercised upon the muscular tissue, as is demonstrated by isolated muscles being as readily influenced when exposed to these vapours.

All examples of general muscular excitation, whether induced indirectly through the nerve (neuro-muscular) or directly by effects upon the muscular tissue (idio-muscular), produce the same arrangements of the limbs in obedience to the strongest set of muscles, which in the hind limbs of the frog are the extensors; but if in the hind limbs the extensor tendons be divided, in any of these cases the limb will be as forcibly flexed as it otherwise would have been extended. In all these cases, therefore, the weaker muscles are powerfully stretched and their elements ruptured; inasmuch as they are compelled to contract contemporaneously with their stronger rivals, so that they are extended by sheer force at a time they are powerfully tending to contract.

In contradistinction to these undeniable cases of muscular contraction we have in Co^2 an agent which favours, or produces, simple rigidity. If frogs be kept for varying periods in Co^2 they will be found to become rigid, but with the peculiarity that no contortion or redisposition of the limbs occurs, the muscles becoming fixed in the position they occupied on the cessation of voluntary movement by the animal. This condition is essentially different to that induced in the former cases.

Now, it has not only been contended that rigor mortis is muscular

contraction, but that it is *the most energetic form* of muscular contraction. On this head Valentin remarks[1] to the following effect. "In the dead bodies of most animals three conditions of the muscular substance succeed each other. There is first a space of time during which the muscles retain a greater or smaller residue of their vital activity, or of their capacity of contracting under proper stimuli. They next experience an *extraordinary contraction* which gives rise to that peculiar phenomenon called the rigor mortis, or the stiffening of death. Finally, as putrefaction advances, the muscular substance softens and dissolves with more or less rapidity. Dr Radcliffe (*Lectures on Epilepsy*) urges that the state of elongation should be regarded as the really active condition of muscular fibre, in which all its vital properties and peculiarities are most strongly marked; whilst the state of contraction is due to its being left to the influence of the attractive forces inherent in its molecules, the *most energetic* operation of which is seen in the *rigor mortis.*" If this be so, why is it, I ask, that no redisposition of the limbs takes place in rigor mortis, after the fashion of the model cases of universal muscular contraction which I have laid before you? In these cases there can be no doubt that we have examples of *energetic* muscular contraction.

The following experiment will illustrate the effects of rigor mortis as observed in the frog in contrast to real cases of contraction in the same animal, May 23, 1863. A female frog, which had died in the act of spawning, exhibited in the hind extremities no susceptibility to galvanism; but the muscles were in a relaxed and flaccid state, i.e. could be easily flexed or extended. From their insusceptibility it was apprehended they would soon pass into the state of rigor; and one limb was placed in the extended and the other in the flexed position. These limbs became rigored, but remained in the position in which they were placed. No redisposition of the limbs occurred in favour of the strongest sets of muscles, which should have been the case if rigor mortis is a contraction. I have seen numbers of frogs in a state of rigor mortis; but I never in a single instance observed any spontaneous rearrangement of the limbs as in the examples of true contraction above cited. Again, in respect to warm-blooded animals; in the hind limb of a mouse the following phenomenon was observed. The extensor muscle of the foot became rigid, i.e. could not be stretched or elongated; while the opposing flexor could still be easily extended, that is to say, the foot could be brought into a right line with the leg, but could not, on the other hand, be bent to more than a rectangle. The flexor muscle did not become rigid

[1] Valentin's *Text Book of Physiology*, by Brinton, p. 374.

for an hour after. Now if the state of rigor in the extensor had been the result of contraction, inasmuch as it was unopposed by any corresponding rigidity of the flexors, it must have resulted in an extension of the limb, which was not the case. The state of rigor, as exhibited in this extensor muscle, can only be regarded as an incapacity on the part of the muscle to be stretched or elongated; that is to say, rigor mortis had suspended the *extensibility* of the muscular structure, nothing more. When this occurs in antagonizing muscles it of course produces complete fixation of the osseous structures to which the muscles are attached, which is the phenomenon of cadaveric rigidity. The rigid condition induced in the frog by prolonged immersion in Co^2 appears to be identical with rigor mortis,[4] and to have nothing in common with the examples of contraction induced by extremes of temperature and exposure to ætherial vapours.

Prop. II.

We come now to the experimental verification of our second proposition.

A vigorous frog was immersed in Co^2. In about an hour it was removed and found to be dead. The muscles still retained their susceptibility to mild galvanism. The entire body was exceedingly flaccid; i.e. the relaxation of the muscles was perfect. As a means of comparison I separated the hind extremities from the body and divided them from each other, of course retaining the bony structures to which the muscles of the thigh were attached. I now galvanized the muscles of one limb in every part till the irritability was entirely exhausted; and no further contraction, however slight, could be produced. The other limb remained perfectly irritable. The muscles which had had their irritability destroyed remained in a perfectly relaxed state; in this respect there was no difference between the two limbs. The irritability of the galvanized limb was destroyed at 6.15 P.M. I now divided the extensor tendon of the foot of this limb and placed it in the extended position to await the accession of rigor. The extensor tendon of the irritable limb was also divided. At 8.25 P.M. there was no return of the slightest irritability in the galvanized limb, but there seemed to be slight evidence of commencing rigor; for if both limbs were held up perpendicularly, so that they might be flexed by the simple act of gravity, the knee-joint of the non-irritable limb did not become flexed to the same extent as that of the other limb. The extensors on the thigh were therefore becoming flexed. On repeating this observation at 10 P.M., the

knee-joint did not bend at all. It is important in this connection to observe that two hours intervened between the destruction of the irritability and the first evidences of rigor mortis. Both limbs were now set aside till morning; the one in which the irritability was destroyed was placed, as before, perfectly straight, the other in the flexed position. At 8 A.M. next morning the limb in which the tendo Achillis was divided was found straight out as when left. The other limb had become rigored in the flexed position in which it was placed.

A second frog was kept in an atmosphere of Co^2 for $5\frac{1}{2}$ hours; after which it was found, by the application of powerful magneto-electricity, that all irritability was destroyed. In spite of the absence of irritability, the whole muscular system was unusually flaccid and relaxed. I cut the flexor tendons of the one foot of this frog and left the foot in the flexed position to test the effect of rigor upon the extensor. At 4 o'clock the next day, after an interval of 20 hours, the muscles were in a state of rigor; but no alteration or redisposition of the limbs had taken place; the foot in which the flexors were cut was not extended in the slightest degree.

In applying this mode of research to warm-blooded animals an obstacle is presented. The opposing muscles of the extremities, by virtue of their elasticity, are so arranged as to exercise a balancing strain upon each other, and so maintain a state of mutual extension. In consequence of this arrangement section of their tendons at once results in a redisposition of the limb. On dividing the flexors the foot becomes extended to nearly a right line with the leg, or, on section of the extensor tendon, is flexed to a rectangle; and, as in muscles, there is both a primary and secondary retraction due entirely to elasticity. It would be impossible to ascertain what belonged to elasticity and what to rigor.

Under these circumstances one method which has suggested itself is that of inducing rigor mortis prematurely in certain sets of muscles by a rapid destruction of the irritability by galvanism. In this manner rigor mortis may be induced in certain sets of muscles long anteriorly to its natural accession in others, in fact, while the irritability and extensibility of their antagonists remains perfect. Under such conditions, if rigor be a contraction, the limb should become flexed or extended as the case may be; whereas I have repeatedly proved by experiment that no modification of position occurs.

Prop. III.

This proposition asserts that, contraction being impossible in the absence of irritability, the occurrence of an interval between the

cessation of irritability and the supervention of rigor mortis proves that the latter cannot be a result of contraction. The evidence of a prolonged interval between the annihilation of irritability and the accession of rigor is contained in the preceding experiments, in which complete relaxation of the muscles obtained for several hours subsequently to the destruction of the vital property of irritability.

In reviewing the whole of my experiments, of which I have been able to give only a few illustrative ones, I am led to the conclusion that rigor mortis is not an affection of the vital property of irritability in muscles, and therefore cannot be regarded as vital contraction; on the contrary, that it is some peculiar alteration in muscular tissue which leads to immobility of its constituent elements, and which, so long as it is present, suspends or interferes with the properties of elasticity and extensibility in muscle; but that the phenomenon of rigor mortis is owing to the temporary suspension of the *latter quality alone*, for it is easy to understand that if antagonizing muscles are rendered incapable of elongation the limb must become fixed.

The circumstances which lead to this non-extensibility or rigidity in muscle cannot, I think, receive a better exposition than that of Brücke and Kühne, viz. that it results from the coagulation of a material contained in the interfibrillar juices of the muscles. If this be correct, the restoration of the elasticity and extensibility of the muscles, and consequently of mobility of the limbs, at the commencement of putrefactive changes, may receive an easy explanation by the hypothesis that these changes first commence in this recently coagulated fluid and restore it to a liquid condition, and thus liberate the muscular elements from their state of bondage.

REVIEWS AND NOTICES OF BOOKS.

ON THE ANATOMY OF VERTEBRATES, by RICHARD OWEN, F.R.S., *Superintendent of the Natural History departments of the British Museum, Foreign Associate of the Institute of France, &c.* Vol. I. FISHES AND REPTILES, and Vol. II. BIRDS AND MAMMALS. London. LONGMAN, GREEN & Co.

THE pride that British anatomists, and indeed the British public, feel in the name of Owen is not likely to be lessened by the two volumes of Comparative Anatomy which he has just given us. To no man of our time is anatomy so much indebted as to Owen. Extending his labours over nearly the whole field he has turned up new facts in almost every direction, and has also greatly enlarged its area. Digging deep into the annals of the past he has told us, perhaps more than any other man, of the denizens of palæontological eras; and his application of deductive methods to ascertained facts is so known and relied upon that searchers in all quarters of the world look to him to unravel the puzzles that fall in their way. His lucid exposition, attractive style, and willingness to unfold his vast stores of knowledge for the benefit of others, have admitted the public to the mysteries of Anatomy, and contributed greatly to foster the growing interest in the science. The nation feels that its great zoological collection is rightly entrusted to his care, and rejoices in the marks of favour which the Sovereign has shown him. It is, however, by steadily carrying out the sentiment, "Every kind of anatomy ought to be so pursued as to deserve the epithet Philosophical[1]," that his reputation has been chiefly won. Dragged down and kept down as anatomy was, and still too much is, to a practical diploma-getting standard, and regarded, as it has ever too much been even by its teachers, as a pathway to hospital appointments and guinea-making, it is quite a relief to turn upon one who, commencing as a medical student, early abandoned the ordinary aims of the profession, devoted himself to pure science, and using as stepping stones, first, St Bartholomew's Museum, then the Museum of the College of Surgeons, and, lastly, the British Museum, has risen and carried his science with him into the regions of Philosophy; and has laboured, not unsuccessfully, to draw others after him, and to show that the most patient observation of facts may be, and ought to be, associated with generalizing deductions as to the great schemes of creation.

[1] *Preface*, p. vii.

The all-impressing steam-rate of the present generation places the man of science in a position somewhat different from that of his predecessors. His heels are close pressed upon by others urging rapidly along in the same course, and ready, probably eager, to mark the slightest stumble and trip him up. The works and opinions of Hunter, Linnæus, and Cuvier—and the remark is still more applicable to their predecessors—were less extensively known and less sharply criticised in their own day than would have been the case now. Reputation, more slowly won it is true, was less challenged and less easily overthrown; and time has shed a halo of respect over their memories, which jealousy has no temptation to disperse. The scientific edifices which they reared were scarcely assailed till after their death; and then the spirit of the assailant is chilled by the want of a living counter-spirit of defence. Now-a-days a man must expect his productions to be instantly pounced upon, turned this way and that, examined through and through, with the penetrating, artificially-aided eye of his compeer, and criticised with the warmth of a compeer, perhaps, with the asperity of an adversary. He must be prepared to pay this penalty for the increased facilities of investigation and publication which modern inventions have given to him and to others. The credit of a discovery or an opinion must rest upon its own individual merit, not upon the respect which may, for other reasons, be due to its author. The more it is foisted upon the latter the stronger will be the tendency and the necessity to bring satire and personal remark into the field, and to use other weapons than those of legitimate argument.

We make these remarks because they have some bearing on the controversy which is hinted at in the preface, and which has attracted so much attention that it cannot be passed over, *sub silentio*, in a review of this work, though we would gladly have done so. Twenty years ago Professor Owen stood almost alone, *facile princeps*. His word was law; and anatomical science was bound by his spell. This was a natural result of his unwearied labour added to his powers of retention, generalization, and exposition; but it was a position not unattended with disadvantage to himself, to his science, and to his fellow-workers. A too ready and unquestioned acceptance of his views is one of the greatest dangers and misfortunes that can befall a man of science; and though the evils resulting from it have been less experienced in the case of Professor Owen than they would have been with most other men, it has not been without its ill effects. Ranging as he has done over so wide a field of anatomical science, contributing by his original investigations to our stock of knowledge in almost every direction, labouring to improve our views of the classification of the animal kingdom and to advance the studies of

homology and palæontology, it were passing strange if a rising, hard-working, quicksighted and eager band of anatomists could not detect some flaws in his works, some vulnerable point, if only the heel of the hero, and should resist the temptation to place an arrow there.

Such a point was no doubt presented in the Sir Robert Rede's lecture delivered in Cambridge, on the *Classification and Geographical distribution of the Mammalia,* p. 25, by the following sentence:

> "In Man the brain presents an ascensive step in development, higher and more strongly marked than that by which the preceding sub-class was distinguished from the one below it. Not only do the cerebral hemispheres overlap the olfactory lobes and cerebellum, but they extend in advance of the one and further back than the other. Their posterior development is so marked that anthropotomists have assigned to that part the character and name of a 'third lobe:' it is peculiar and common to the genus *Homo:* equally peculiar is the 'posterior horn of the lateral ventricle' and the 'hippocampus minor,' which characterize the hind lobe of each hemisphere[1]."

Whatever view may be taken of the desirableness of regarding "the *Homo* as not merely a representative of a distinct order, but of a distinct subclass, of the Mammalia, for which I propose the name of ARCHENCEPHALA" (p. 26), it was unfortunate, to say the least of it, that mention was made of the presence of the 'posterior horn of the lateral ventricle' and of the 'hippocampus minor' as among the distinguishing characteristics which mark off the subclass from the rest of the animal kingdom. True, it is not clear that any great stress is laid on them; and, at pp. 49 and 50, where man's claims for ordinal distinction are set forth at greater length—the erect stature, the bipedal gait, the mental powers associated with extraordinarily developed brain, the unopposable hallux, the short broad pelvis, the widely separated shoulders, the hand of matchless perfection of structure, &c.—no mention is made of the posterior horn of the cerebral ventricle or its hippocampus. The distinctive features seem to be there regarded as quite sufficient without them; and one would have thought our author might have been content to let them go and to take his stand without them, as soon as it was shown, and clearly shown as it has been, that they cannot be regarded as characteristics at all,

[1] In Vol. II. p. 272, the above sentence is repeated with some modification, thus: "In man the brain presents an ascensive step in development, higher and more strongly marked than that by which the preceding subclass was distinguished from the one below it. Although in the highest *Gyrencephala* the cerebrum may extend over the cerebellum, in man not only do the cerebral hemispheres overlap the olfactory lobes and the cerebellum, but they extend in advance of the one and further back than the other. Their posterior development is so marked, that anatomists have assigned to that part the character of a third lobe; it is peculiar, with its proportionally developed posterior ventricular horn and 'hippocampus minor,' to the genus *Homo.*" The figures (148—149) of the brain of the 'orang-ætan' show a greater overlapping of the cerebellum by the cerebrum than does the figure of the chimpanzee's brain (7 in the 'classification').

indeed, that they are features of greater relative prominence in some others of the mammals than they are in man. There would have been then no need of a controversy which we have witnessed with regret, and no need of the peculiar train of argument in the preface of the present work (xvi to xxi), which would seem to have for its object to prove that the presence or absence of a given feature or structure may be taken as a zoological character irrespective of its being an anatomical fact.

σοφόν τοι κἂν κακοῖς, ἃ δεῖ, φρονεῖν.

Indeed the main defect in the present volumes arises from the circumstance that the author has not taken sufficient account of the views and observations of others where they have differed from his own. It is not to be supposed that they are invariably wrong and that he has invariably been right. Yet the latter assumption is rather too prominent; and the author stands boldly and unswervingly on his own premises, however they may have been disputed or even disproved, and reasons from them almost as axioms. This detracts unquestionably somewhat from the value of the work and the pleasure felt in its perusal. For instance, the connection of the scapular arch and the upper limb with the occiput of the archetypal skeleton, which is unhesitatingly maintained, although such a view now finds few advocates, and, although, it is remarkably at variance with many facts and with figures (30 and 63) in the present work, of the dog-fish and the sea-hound in which the scapular arch is seen to be distanced from the skull by a series of branchial arches suspended from the anterior vertebræ of the trunk and intervening between it and the hyoidean arch. The adoption of this view, to which the Professor so pertinaciously adheres, is only to be explained on the supposition that he was early impressed by the study of the skeleton of the osseous fishes, so that he came to regard it as typical, and that his ideas, being first cast in that mould, have resisted all the remodelling which more extended observation might have given them. Yet we find him speaking of the 'bony fishes' as "the more specially developed and divergent cold-blooded vertebrates"; and, in accordance with the plan adopted in the work of ascending from the more simple to the more complex, the description of the skull in them is given after that of the 'cartilaginous fishes' and the 'batrachians.' Equally subject to objections which have not been answered, perhaps, because they are unanswerable, are the homological adjustment of certain of the cranial bones, especially the mastoid and squamous parts of the temporal, the basi-sphenoid, the components of the prefrontal vertebra, and the mandibular and hyoidean arches.

A valuable work, nevertheless, it is, a work to be read and read

again and long to be referred to, a work of which we may all be proud and all profit by, and which will take and retain its place among the best standard works of science.

An interesting illustration of the bearing of palæontology upon anatomy and of the mode in which the one elucidates and supplements the other is found in the following paragraph, p. xxxi.

"A corresponding modification of the caudal vertebræ prevails in neozoic birds; but the embryos of the existing species show the terminal vertebræ distinct, in a tapering series, before they are massed into the 'ploughshare bone;' and such, doubtless, was the law of development in all the extinct species which have left tertiary ornitholites. But the earliest and as yet sole evidence of the fossil skeleton of a mesozoic bird shows the retention of the embryo condition, with ordinary growth of the vertebræ."

In the concluding part of the preface Prof. Owen expresses

"every disposition to acquire information and receive instruction as to how species become such,"

dilates to some extent in

"the operation of natural law or 'secondary cause' in the succession and progression of organised species," as illustrated by "the unity of plan underlying the diversity of animal structures, and by the determinations of special and general homology; by the discovery of the law of 'Irrelative repetition;' by observation of the analogies of transitory embryonal stages in a higher animal to the matured forms of lower animals; and by the evidence that in the scale of existing nature, as in the development of the individual, and in the succession of species in time, there is exemplified an ascent from the general or lower to the particular or higher condition of organism."

He remarks that the wings of the New Zealand birds (*Dinornis Apteryx*, &c.)

"like the eyes of the cavern fishes and crustaceans would seem to have degenerated for want of use;"

while

"their legs, by which locomotion was exclusively exercised, have gained in strength and size."

He observes that if

"conditions change, then the variety of the species at an antecedent date and state of things may become the type-form of the species at a later date, and in an altered state of things."

He shows no *a priori* objections to Mr Darwin's exemplifications of the

"reciprocal influence of external conditions and inherent tendencies to variety in carrying on, as he believes, the deviations from type to specific and higher degrees of difference." "All these, however, are conceptions of what may have, not observations of what have, originated a species. Applied to the structures which differentiate *Troglodytes* from *Homo*, or *Chiromys* from *Lemur*, they are powerless to explain them."

He is still compelled therefore, as in 1849, to confess ignorance of the mode of operation of the natural law or secondary cause of the succession of species on the earth.

"But that it is an 'orderly succession,' or according to law, and also 'progressive,' or in the ascending course, is evident from actual knowledge of extinct species."

These remarks seem to indicate the true philosophic spirit, because the unprejudiced one, in which this interesting and difficult question should be approached. The very fact of an enquiry into the causation of species, presenting, as it does, to the minds of some the nature of forbidden ground because they have seen or thought they saw in its discussion a disposition to lower the estimate of creative power, has given it a sort of fascination over the minds and the judgments of others and has imparted unusual warmth to the discussions upon it. Under such circumstances a fair consideration of its real quality is scarcely to be expected. It assumes the character of a party question, with a religious tinge, and loses proportionately in scientific merit. Professor Owen views it, if we understand him aright, as a question not to be suppressed by a veto of imaginary religious feeling, but as affording a legitimate ground for careful investigation and rational induction, free from prejudice on the one hand or hasty assumption on the other. In this we entirely agree with him. As nothing can be more damaging to religion than the making it a stumblingblock to science and the expressing of unworthy apprehensions of science and scientific men, so nothing is more detrimental to science than the indulgence in hasty generalizations and crude assertions upon a subject which is confessedly one of extreme difficulty and in which religious feeling is, rightly or wrongly, found to be involved. Perfectly ready, almost longing as we may be, to welcome information as to the origin of species, and believing that evidence as to the mutation of species and the working of secondary laws in forming the steps of that great ladder which commences in mineral atoms and culminates in man would lead us to higher conceptions of creative power than we now have, we are nevertheless compelled to sympathize with Professor Owen's confession of ignorance on this head. Interesting speculations there have been; and much they have done to familiarize men's minds with the idea of operations through intervening law, instead of being easily satisfied with constant reference to direct agency: still they are little more than speculations. An insight into the law and a knowledge of the manner in which the end is accomplished seem almost as distant as ever.

The following passage on the nature of limbs bears upon this

question and is a fair specimen of the author's style and mode of viewing such subjects.

"The tadpole affords a significant example of the transmutation of a natatory to a saltatory type of hind-limb, irrespective of efforts and exercises through successive generations producing and accumulating small changes, and independently of any selection by nature of such generations as were enabled, through the accidental variety of a slightly lengthened hind-limb, to conquer in the battle of life, and to transmit the tendency towards such disproportion to their posterity.

"If the law by which so much of the change of structure adapted to terrestrial life takes place in the active independent aquatic animal be a mystery, and seeming exception, it does not the less impress the believer in the derivative origin of species with the idea of unseen and undiscovered powers, that may operate in producing such result, 'according to a natural Law or Secondary Cause.'"

In the chapter on the eggs of birds we find the following:

"The main function of the chalazæ is to keep the yolk more steady in the albumen, and to moderate the effects of any violent movement or rotation of the egg. The domed form of the hard shell enables it to bear the superincumbent weight of the brooding mother. How these modifications of the oviparous egg in anticipatory relation to the needs and conditions of incubation can be brought about by 'selective' or other operations of an unintelligent nature is not conceivable by me."

The present volumes are a continuation of the summary of the course of Lectures on Comparative Anatomy and Physiology delivered in the theatre of the Royal College of Surgeons between the years 1843 and 1854. The part of the course (Vol. I.) on the Comparative Anatomy and Physiology of the Invertebrate animals was published in 1843 and went through a second edition in 1855. In 1846, Vol. II. appeared containing the Lectures on Fishes as the first part of the course on the Comparative Anatomy and Physiology of the vertebrate Animals. Volume I. now issued includes Fishes and Reptiles, and is therefore to a considerable extent a reprint of the Vol. II. before given; indeed in the parts relating to Fishes it is so almost entirely. We think therefore it would have been better and more acceptable to the student if the whole course on Invertebrate as well as Vertebrate animals had been issued together as one continuous treatise. Perhaps in a future edition this may be done. Other portions—those on Birds, Monotremes and Marsupials have already appeared in the Cyclopedia of Anatomy and have not undergone much alteration.

The primary division of Vertebrates into *Hæmatocryal*, or cold-blooded—including Fishes and Reptiles,—and *Hæmatothermal*, or warm-blooded—including Birds and Mammals,—is adopted because it suits the author's purpose.

Perhaps it will bear scrutiny as well as any other; for the higher temperature of the 'hæmatothermals' is not merely an expression of greater molecular changes, but is associated with difference of

character in most of the important organs and systems, as indicated in the beginning of Vol. II.—in the greater quantity of the blood and the greater proportion of its organic principles and its greater depth of colour, in the four-chambered heart with distinct pulmonary and systematic circulation; in the spongy lungs; in the greater proportionate mass of the nervous system, and especially of the precephalon; in the deeper colour and the longer and more energetic contractions of the muscular fibre. The blood of the 'hæmatocrya' is "cold or with a temperature rarely above that of the surrounding medium;" that of the 'hæmatotherma' is from 106° to 112° in birds, 105° in the whale, 100° in man and other mammals. The loss of temperature during hybernation—that of the bat falling as low as 40°—need not be regarded as an exception, the animal being then maintained only in a potential condition.

The four great classes *Pisces, Reptilia, Aves, Mammalia,* are retained as distinguished from one another by the broad and well marked characters afforded by the respiratory system, without distinguishing the Amphibia as a separate class as is done by Prof. Huxley and some others. This we think is, on the whole, wise, inasmuch as the multiplication of classes is not desirable; and we have never felt that the peculiarities of Amphibia are sufficient to justify their complete separation from Reptilia. It may however be remarked, in passing, that the sort of correlation of lungs and feet mentioned at p. 5, is scarcely borne out by the characters of the limbs in cetaceans and ophidians. In short, the characters of the limbs throughout the animal series evidently have relation not to the characters of the respiratory apparatus alone but to the general structure of the animal and especially to the circumstances under which they have to be used.

"Turning into the dark vistas of the remote past" and "combining with palæontological research the results of anatomical developmental scrutiny of existing vertebrates" our author gives the following five subclasses of Hæmatocrya. I. DERMOPTERI (the Lancelet, Hagfish and Lamprey), i.e. the vermiform, limbless, ribless fishes with membrano-cartilaginous and notochordal skeleton. II. TELEOSTOMI, or osseous fishes. III. PLAGIOSTOMI, or cartilaginous fishes, including Lepidosiren. IV. DIPNOA, or Amphibia. V. MONOPNOA, or Reptiles. The two latter subclasses include several extinct orders. The arrangement differs, therefore, very little from that usually made.

In chapter II. "in the osseous system of the Hæmatocrya," amid so much that is good on the structure, development and growth of bone, it is rather surprising to find, at p. 24, such a sentence as the following, with reference to the changes that are wrought in bone, to adapt it to its destined office, by the removal of parts previously formed.

"In fishes, indeed, we observe a simple unmodified increase. To whatever extent the bone is ossified, that part remains, and consequently most of the bones of fishes are solid or spongy in their interior, except where the ossification has been restricted to the surface of the primary gristly mould."

Upon what grounds a renunciation is thus made, in the case of Fishes, of the most important characteristic of bone, as distinguished from shell—the property, that is, of undergoing absorption as well as increase, whereby it is adapted to the varying size and conditions of the body and is fitted for the purposes of an internal skeleton—we are not told. The necessity for such a property seems quite, or nearly, as great in the fish as in the mammal; and the evidences of its influence are clearly marked in the maintenance of the proper relative size of the various holes and canals and, particularly, in the progressive enlargement of the neural and hæmal arches of the vertebræ, which, forasmuch as those parts are, in most fishes, early confluent with the centres, can only take place by absorption of their inner surfaces while addition is being made on their exterior.

Commencing with the osteology and myology of cold-blooded vertebrates, he considers them chiefly from a homological point of view, and aims, with much success,

"At relieving the dryness of descriptive detail, and at connecting the multifarious particulars of this difficult part of Comparative Anatomy in natural order, so as to be easily retained in the memory, by referring to the relations which the bones and muscles of Fishes and Reptiles bear to the general plan of vertebrate organisation, and by indicating their analogies to transitory states of structure in the embryo of higher animals, and to those answerable conditions of the mature skeleton which, in longer lapse of time, have successively prevailed and passed away in the generations of species that have left recognisable remains in the superimposed strata of the earth's crust."

The gradations of development of vertebræ, from their first faint indications in the notochordal capsule of the Lancelet, through the cartilaginous and increasingly osseous conditions of the Myxine, Lepidosiren, Sharks and osseous fishes, to the procælian or completely ossified and even coalesced state in reptiles, is well traced in this chapter. An equally good account of the brain-case follows; and the comparison of the brain-case with the vertebral column in these animals, respectively, adds strong evidence in favour of the vertebral theory of the skull which the opponents of that view will do well to examine. Especially should they remark the mode in which the base of the skull is shown to be "first formed," as in the Lancelet, "by the anterior prolongation of the notochord and the expansion therefrom of its capsule; and that the cranial cavity results from the extension of the outer layer of that membrane over the anterior end of the nervous

axis," p. 82. The capsules for the organs of special sense are next added (in the Lamprey), and the cartilaginous tissue is developed in the notochordal sheath at the base and sides of the cranium; and these become ossified in Lepidosiren. Indeed the whole of this part of the work presents an admirable illustration of the analytical and synthetical 'way' of anatomy; the extensive knowledge and the calculating powers of the author peculiarly fitting him for such a task. Not that he has omitted, as has sometimes been laid to his charge, the information to be derived from the mode of development of the individual classes. He draws from both sources of information—the development of the parts embryologically is taken in connection with their position, function, relations and modification to suit particular requirements as well as serially—which we need scarcely say is the only true mode of arriving at correct conclusions. Although therefore we may not agree with all his decisions, we are bound to confess that he has collected his evidence with infinite pains from the legitimate sources and weighed it carefully and fairly. The faults, if there be faults, in his homological scheme are due to the difficulties attendant on the attempt to draw out such a scheme, difficulties that have been experienced by every anatomist who has essayed to systematize the complex and varying structure of the vertebrate skull.

The chief of those which we are disposed to regard as faults are due, we think, as already hinted, to his having taken the skull of osseous fishes as a starting point and attempted to harmonize the crania of other vertebrates with it. The skull of these fishes, being the most complete of all, is more likely to add to than unravel the puzzle, and requires to be explained by a careful consideration and comparison with others rather than serves as the key to their cipher. The various faults or questionable features are all, or nearly all, attributable to this. Thus the appending the scapular arch to the occiput throughout the vertebrate series, because, for obvious and especial reasons, it happens to be so placed in fishes, throws, to say the least, a doubt upon his view of the position of all the other hæmal arches of the skull. For if the scapular arch be not properly disposed by him, then neither are those in advance of it—the hyoidean, mandibular and maxillary. Moreover the doubt spreads from them to the parapophysial bones from which those arches are suspended, or are supposed to be suspended, especially the 'mastoids' and 'prefrontals;' and this has led on to the, at least, questionable view of the relation of the 'malar' and 'squamous' (the presence of which is not admitted in the fish) as a diverging appendage to the maxillary. We could wish that the saw had not been used so ruthlessly to cut into a basi- and a pre-sphenoid the gordian-knot-bone beneath the base of the piscean and batrachian skull, which Professor Huxley, with

hesitation but more probability, calls 'parasphenoid;' and we fear that the hard problem of the homologies of the several parts of the temporal bone has as yet resisted the solving skill of Hallmann, Owen and Huxley, though their efforts may have prepared the way to success for some more fortunate anatomist.

The homological study of the skull revived by Owen, upon the plan indicated by Oken, has been freely and ably discussed by Huxley[1]; and though the latter has objected, upon insufficient grounds we think, to the 'vertebral theory' of Oken and Owen, yet the segmental disposition of its components, which is after all the basis of the 'vertebral theory,' is accepted by him. The difference, therefore, on this fundamental question is not so great as might seem from the naked assertion that the one repudiates while the other accepts the vertebral theory. Both agree that the skull is composed of segments placed in serial order in the longitudinal axis of the body; and it is beside our present mark to enter into the question whether or not the term 'vertebral' should be applied to these segments.

They are also agreed as to the number and chief constituents of the segments. Thus the *first*, or 'occipital segment,' includes the 'basi-occipital,' the 'exoccipitals,' and the 'supraoccipital,' which together make up the 'occipital' of human anatomy. The *second*, or 'parietal segment,' includes the 'basi-sphenoid,' or hinder part of the centrum of the sphenoid, the 'ali-sphenoids,' and the 'parietals.' The *third*, or 'frontal segment,' includes the 'presphenoid,' or fore part of the centrum of the sphenoid, the 'orbito-sphenoids,' and the 'frontal.' The *fourth*, or 'nasal,' which is the foremost segment, includes the 'ethnoid,' 'vomer,' and 'nasal' bones. They are further agreed that certain bones—the 'petrous' or 'periotic' bones and the 'turbinate' bones—are ossifications of parts of the auditory and nasal apparatus. It may be said, therefore, that in the main points of detail of the segmental construction of the skull and the composition of its basal and neural parts in mammals, these two anatomists are pretty much agreed.

In the comparison, however, of the components of the respective segments in the mammalian with those in the reptilian and piscean skull differences arise, which result no doubt in part from the different direction in which each approaches the subject. Owen, commencing with the fish, and founding his plan much upon the observation of the fish's skull, works his way upwards. Huxley, on the other hand, commencing with man, travels down to the reptile and fish. Owen lays more stress upon 'serial,' Huxley upon 'embryonic' development.

The 'occipital' segment is so far similar in the several classes

[1] *Lectures on the Elements of Comparative Anatomy.* 1864.

that the comparison of its chief constituents does not admit of much question. Its basal, exoccipital, and supra-occipital elements, where present, are easily recognised. But the temporal bone continues, and probably long will continue, to furnish ample scope for the picking propensities of anatomists. There is no other part of the skeleton represented by a single bone in one class (mammal) which is so much divided in the other classes, and the constituents of which are subject to so much variation; and there is none, accordingly, which has presented so much difficulty to anatomists and been the subject of so great difference of opinion. Indeed, at the present time, there is no one of its several component parts respecting the homologies of which anatomists are agreed.

Take the 'sense-capsule' or 'petrous' or 'periotic' part, for it bears each of these names. Owen conceives that, as the organ of hearing becomes simplified in reptiles and fishes, this part diminishes and finally disappears; so that in the reptile it is in very scanty proportions, the covering of the auditory apparatus being, as far as it is required, supplied by the parts of the occipital (the paroccipital and the supraoccipital) and the alisphenoid. Huxley, on the contrary, conceives that this 'periotic'—which he finds composed of three parts (a 'pro-otic,' an 'opisthotic,' and an 'epiotic')—rather increases in relative importance in the inferior animals and encroaches upon the territory of its neighbours. Thus Owen's 'paroccipital' and 'alisphenoid' in the reptile are Huxley's 'epiotic' and 'pro-otic.'

Again, Owen's 'mastoid' in the reptile and fish is with Huxley and Humphry the 'squamous;' and his 'squamous' is their 'quadrato-jugal.' The 'quadrate' of the bird and reptile and the four bones corresponding with it and connecting the lower jaw with the skull in the fish, are by Owen regarded as representing the 'tympanic bone,' by Huxley as representing it with certain of the 'ossicula auditus,' and by Humphry as the 'glenoid' part of the temporal.

It is clear, therefore, that much has to be done before we can consider the homologies of the temporal bone to be settled.

The relation of the inferior arches of the skull—the 'hyoidean,' 'mandibular' and 'maxillary,'—to the digestive and respiratory tubes are clearly indicative of their visceral character, and justify Owen's comparison of them to the pleural and sternal parts of the thorax as obviously as the relations of the superior arches to the brain indicate their neural character and show them to correspond with the neural arches of vertebræ. The points of their attachment vary somewhat, but less than might have been expected in the several classes of animals. Whereas the scapular arch, usually situate at some distance behind the head, is in the osseous fishes and Lepidosiren attached to the occiput. The assuming this to be its typical position

seems to us, as before intimated, the weakest feature in the Owenian plan; and it does not appear to be strengthened by any arguments adduced in these volumes from the reptilian and higher classes.

With this exception, the mode in which the 'limbs' or 'appendages' are treated is lucid and philosophical. They are shown to "commence as a bud or fold of skin, within which is formed the framework, in texture and structure according to the work to be done." In fishes this framework consists of a number of rays or 'digits.' "The vegetative repetition of digits and joints, and the vegetative sameness of form in those multiplied peripheral parts of the fins of fishes, accord with the characters of all other organs on their first introduction into the animal series" (p. 166). Gradually they become more and more projected by the development, first, of the distal, then of the proximal segments of the limbs. Thus in the Angler[1] (Lophius) and the Shark the carpals only are found, and constitute the second segment that connects the rays with the scapular arch. In Polypterus a third segment dawns in the presence of two small cartilages representing the radius and ulna and forming the medium of attachment with the scapular arch. These are sometimes ankylosed with the coracoid, as in Silurus, more generally free, and sometimes, as in the Opah, the Cock-fish, and the Flying-fish, attain to great length. Beyond this, that is, beyond the development of these three segments, the pectoral limb does not advance in fishes, the humeral segment not being formed; and in the ventral fins even these are not developed, the rays resting directly upon the pelvic bones. In all higher vertebrates, whether they be inhabitants of the water or not, the fourth or humeral segment is present, and is associated with a diminution of the number of the distal elements; so that, as we have already stated, the condition of the limb is dependent upon its relation to other points of structure in the animal, as well as upon external circumstances.

The position of the ventral fins in fishes, varying so greatly as to induce Linnæus to make it the basis of his classification, an absence of direct connection with the vertebral column and the mode in which they bud, as it were, from the skin of the belly, seem rather to suggest the question whether they, and if they the pectoral fins and the limbs of animals generally, are to be regarded as parts of the vertebral system at all. May they not, like the dorsal, anal, and caudal fins, be special developments of the cutaneous or external

[1] The presence in Lophius of a row of cartilages supporting the rays and connecting them with the bones called carpal, does not appear to be recognised by Owen; but they form a distinct feature and throw some doubt upon his view of the homologies of this limb. It would seem quite probable that they represent the carpal series, and that the two bones called by him 'carpals,' are in reality the 'radius' and 'ulna.'

embryonic layer, formed at such parts as may be required, and attaching themselves, according to circumstances, to this or that part of the vertebral system: it may be to the cranium or the thorax or some other. Does not this view bring them better into relation with the limbs of the several members of the annulate class, which are clearly parts of the external or dermal system.

In the myological parts of the work Professor Owen dwells upon the disposition of the muscles in transverse segments or 'myocomes' which are connected by intervening strata of fibrous, or, it may be, osseous tissue, as in the case of the ribs. These segments he shows, in fishes, to correspond generally with the osseous or vertebral segments; and he traces them forwards into the head between the scapular, hyoidean, and maxillary arches. In this region, however, they undergo that change, analogous to ankylosis, which justifies their being regarded as distinct longitudinal muscles; and in the higher animals the ankylosis taking place in other parts of the body leads to the formation of the longitudinal masses of muscles—the 'sacrolumbalis,' 'longissimus dorsi,' 'spinalis dorsi,' and others surrounding the spine. Obvious traces however of the segmental disposition remain in the 'intercostals,' in the abdominal muscles of reptiles, and in the 'lineæ transversæ' of the human 'rectus abdominis.'

The opinion expressed (p. 220) that flexion of the second, or elbow, joint of the fore-limb corresponds with extension of the second, or knee, joint of the hind-limb, that the flexors of the arm—the 'biceps' and 'brachialis anticus'—are homologous with the extensors—the 'quadriceps'—of the leg, and that therefore the 'patella' is homologous with an ossicle sometimes developed in the tendon of the 'biceps,' does not seem to rest on very strong foundation, and will not, we suspect, carry much conviction to those who take the opposite view and regard the 'patella' as homologous with the extremity of the olecranon, or at any rate with an ossicle developed in the tendon of the 'triceps extensor cubiti,' when the olecranon is abortive, as is the case in the Bat. Indeed there is often much difficulty in determining the homologies of the muscles; and their characters "exemplify the greater degree in which the adaptive principle prevails over the archetypal one in the soft than in the hard parts of the frame," p. 231.

The account of the nervous system is very thorough, comprising a description of its varieties in a large number of the members of the respective classes.

The 'encephalon' is regarded as being comprised of four primary portions or segments. Of these the hindmost or 'epencephalon' consists of the medulla oblongata with the cerebellum; and, in fishes, where this part is relatively larger and more complex and diversified

than in any of the higher classes of vertebrates, of the vagal and trigeminal lobes and the nodulus, though these are not always present. The next succeeding primary division, the 'mesencephalon,' consists of two upper spheroidal bodies, the 'optic lobes' of "two lower subspherical bodies, the 'hypoaria,' with intervening connecting walls enclosing a cavity, called the third ventricle, which is prolonged downwards into the pedicle of the 'hypophysis,' or pituitary gland, and upward into that of the 'conarium,' or pineal gland." Each optic lobe contains a ventricle, on the floor of which, in fishes, are from one to four small white 'tubercles' and a 'torus.' These do not correspond, as they have been supposed to do by some anatomists, with the 'corpora quadrigemina,' or 'thalamus opticus,' or 'corpus striatum,' of the mammal's brain. They, as well as the 'hypoaria,' are peculiar to fishes. The optic lobes are grooved transversely in serpents. Thirdly, the 'prosencephalon,' consisting of two small masses, composed in their superficies of grey vascular neurine, usually in close contact with the optic lobes and solid, but in some—Lepidosiren and Plagiostomes,—having a ventricular fissure and a choroid plexus in their deeper parts, which shows them to be homologous not with the 'corpora striata,' "that is a medium of transmission," but with the 'cerebral lobes' of mammals, that is, "the seat of the terminal expansion of the radiating medullary fibres of the cerebral crura." In serpents the ventricle is more marked, a 'corpus striatum' projects into it from the under and outer side; and it is continued forwards into the olfactory lobe. Fourthly, the 'rhinencephalon,' or olfactory lobes, which are always present, though they are sometimes at a distance from the prosencephalon, and sometimes close to it or even sheltered by it.

The Reptilian brain, with the exception of the crocodile's, in which the relative size of the cerebral lobes is greater, shows no considerable advance upon that of the fish.

> "The brain of the bird differs from that of the reptile in the superior size of the cerebrum and cerebellum, together with the folding of the latter, which relates probably to the higher locomotive powers of the bird; it differs from the brain of the mammal in the absence or small beginning of the fornix, and of the lateral lobes of the cerebellum; it differs from the brain of every other class in the lateral and inferior position of the optic lobes."

The comparison of the Reptilian and Avian brain during the development of the latter is thus instituted:

> "In the brain of the chick at the eighth day of incubation the fourth ventricle is exposed by divergence of the dorsal myelonal columns, which now have the name of 'posterior pyramids;' the plate of neurine developed from them to bridge over the ventricle shows the same incipient state of the cerebellum as in the *Batrachia*. It next expands at the middle and

represents the condition of the cerebellum in the lizard: continuing to grow, the cerebellum covers, at the sixteenth day of incubation, the fourth ventricle, and has a smooth exterior as in the crocodile and turtle. Towards the close of incubation the cerebellum presses forward toward the cerebrum, and seems mechanically to push aside the optic lobes; the multiplied grey matter of its superficies is disposed in transverse folds: small beginnings of lateral lobes are present in many birds. The white neurine continues to accumulate beneath the grey, and reduces the cavity of the originally vascular cerebellum to a fissure, which retains its primitive connection with the fourth ventricle." "The optic lobes in the embryo are smooth vesicles of white neurine, in contact with each other, as in *Reptilia:* they are at first oblong, as in *Batrachia;* next acquire a spheroid figure, as in lizards, and then assume their ornithic character by diverging laterally toward the lower plane of the brain." Vol. II. pp. 118, 121.

The author does not depart from his previously expressed opinion that the spinal cord of vertebrates is the analogue of the abdominal cord of insects, and that the sympathetic system "is an offset or subordinate element of the general myeloncephalous series of nerve-organs," and "differentiated by progressive steps." He takes no notice of the view suggested by Von Baer and adopted by Huxley—a view based partly upon the position of the respective organs, and partly upon the manner of their development—that the sympathetic is the correspondent of the ganglionated nervous centres of the invertebrata, and that these admit of no comparison with the cerebro-spinal centres of the vertebrata. May it not be that in this, as in so many other instances, the truth lies somewhere between these conflicting views? that the ganglionated chain of the invertebrates is the representative, not of the cerebro-spinal nor of the sympathetic system of the vertebrates, but of both? Functionally, at any rate, it is pretty clear that this is so; and our knowledge of the changes that take place in the earlier periods of embryonic life is scarcely precise enough to warrant our dogmatizing upon it in opposition to strong functional evidence.

When alluding to the chief peculiarity of the organ of vision in Ophidians, the manner, namely, in which, for defensive purposes, the integument is continued directly over the eye, adhering to the outer part of the conjunctive, which forms a closed sac in front of the eye, Prof. Owen observes:

"It is interesting to note the correspondence of condition between the eye and ear, in regard to the fore-court of each organ, which serpents exclusively exemplify, among air-breathing vertebrates. The tympanic chamber parallels the conjunctive chamber; both are closed externally,—the one by the ear-drum, the other by the autocular membrane: the lachrymal canal is the homotype of the eustachian."

The account of the teeth and alimentary canal is clear and full, without containing much new matter; and there is no great scope for generalization. The following passage shows that it is not easy

to establish a relation between the character of the teeth and the form of the stomach:

"Such are the observed extremes of the modifications of the stomach in fishes, which it will be seen, therefore, are far from according with or paralleling those of the dental system. There is often, indeed, no essential difference of form in the stomach of a fish with exclusively laniary teeth, e.g. the carnivorous salmon, and in that of one with exclusively molar teeth, e.g. the herbivorous carp. The Ætobates, whose teeth form a crushing pavement, has a stomach similar in shape and size to that in the common ray, in which every tooth is conical and sharp-pointed."

The spiral valve in the large intestines of Plagiostomes, which, by giving an extension to the mucous membrane, permits an economy of space in the abdominal cavity, is connected with "the necessity for reducing the mass and weight of the abdominal contents in the active high-swimming sharks, which have no swim-bladder; the essential part of an intestine being its secerning and absorbing surface, we see in them the requisite extent of the vasculo-mucous membrane packed in the smallest compass, and associated with the least possible quantity of accessory muscular and serous tissues." Instances are, however, mentioned in which the spiral valve is associated with the swim-bladder.

With regard to the homologies of the vascular system Prof. Owen, following much the views of Rathke, says:

"The precaval veins," formed on each side by the confluence of the jugular and cardinal vein, "are the homologues of the two 'superior cavæ' in reptiles and birds, which receive the so-called 'azygos' veins or reduced homologues of the 'venæ cardinales' of fishes: in the higher mammals and in man they are concentrated into a single 'superior vena cava,' receiving the 'venæ cardinales' by a common trunk, thence called 'azygos' in Anthropotomy. The anatomical student is usually introduced to the cardinal veins, as represented by their single homologue in the human subject, where their normal symmetrical character becomes masked by an extreme modification, and where the name 'azygos' is applicable only to so exceptional a condition."

The 'vena neuralis' runs parallel with the 'vena cardinalis,' but above the vertebral bodies in the neural canal. It receives neural and myelonal twigs; and communicating branches between it and the cardinal veins perforate the substance of the kidneys and receive the 'renal veins.'

"The visceral system of veins commences in osseous fishes by the capillaries of the stomach and intestines, pancreatic cæca and spleen, of the generative organs and air-bladder: these, by progressive union and reunion, constitute either a single trunk, which forms the portal arterial vein of the liver; or, as in the Perch, a second trunk, the true homologue of the 'inferior cava,' which returns the blood from the genital organs and air-bladder to the auricular sinus, without previous ramification in the liver; the portal trunk being formed only by the veins of the alimentary canal and its appendages" (p. 467).

"The venous system of Batrachians resembles that of fishes in the degree in which the species retain the piscine character. The cardinal veins, essentially those which return the blood from the osseous and muscular segments of the trunk, are largest in Perennibranchs, and decrease, as the hind-limbs acquire more size and power, in the newts and land-salamanders, until, in the tail-less and long-legged frogs and toads, the primitive venous trunk of the body is reduced to the condition of the 'azygos' vein in mammals, and the great bulk of the blood is submitted to the influence of the kidneys and liver before it is returned to the heart."

In most Reptiles the blood of the lower limbs and tail is described as being conveyed partly by a 'reni-portal' vein to the kidney, and partly by an 'umbilical' or 'subabdominal' vein, which collects the blood from the ventral walls of the trunk and receives the gastro-intestinal pancreatic and splenic veins, so forming the great 'portal' vein and penetrating the liver. The renal veins unite with the ovarian or testicular veins to form the 'post-caval'—the representative of the mammalian posterior cava—which traverses the liver and receives the hepatic veins. A small 'cardinal' or 'azygos' vein, returning part of the blood from the tail, advances along the back part of the abdominal cavity, receiving the segmental or vertebral veins, and terminates in the left precaval. The blood from the head and fore-limbs is conveyed by a pair of precavals.

"Physiologically the heart of fishes," consisting commonly of four chambers, the 'sinus communis,' the 'auricle,' the 'ventricle,' and the 'bulbus arteriosus,' "answers to the venous or pulmonary division, viz. the right auricle and ventricle of the mammalian heart, and its quadripartite structure in fishes illustrates the law of vegetative repetition, rather than that of true physiological complication. The auricle and the ventricle are, however, alone proper to the heart itself: the sinus is a development of the termination of the venous system, as the muscular bulb is a superaddition to the commencement of the arterial trunk. The heart of fishes with the muscular branchial artery is the 'homologue' of the left auricle, ventricle, and aorta in higher vertebrates; but it performs a function 'analogous' to that of the pulmonic auricle and ventricle in them."

The distinction between 'analogy' and 'homology' in this instance does not seem to rest upon very sure grounds. We do not see why the heart of the fish should not be regarded as homologous with the right or pulmonary, as much as with the left or systemic, side of the heart in the higher vertebrates. Indeed, the metamorphoses of the vascular system in the frog, the graduated division of the heart in reptiles, and the mode of its development in birds and mammals, seem to show clearly that the ventricle of the fish, at any rate, is the homologue not of either the right or the left ventricle of the higher vertebrates, but of both ventricles. And with regard to the auricles the serial development of them in Hæmatocrya, as traced by Prof. Owen, indicates a gradual addition of the left auricle, proving that the one first introduced, that is, the auricle of the fish,

is the homologue not of the left but of the right auricle of higher vertebrates. Thus

> "In Lepidosiren the vein from the lung-like air-bladders traverses the [single] auricle and opens directly into the ventricle. In Siren the pulmonary vein dilates, before communicating with the ventricle, into a small auricle, which is not outwardly distinct from the much larger auricle receiving the veins of the body;" and "the pulmonic auricle augments in size with the more exclusive share taken by the lungs in respiration" (p. 506). In scaled reptiles also "the returning blood from the expanding lungs leads to the development of a distinct chamber in the auricle, which finally becomes the left auricle."

The serial development of the parts of generation, with the parallelism of the male and female organs, is traced through four grades of complexity in the fish. *First,* there is the essential organ, distinguished as testis or ovarium only by microscopical examination of its contents, single and in the median line, as in the eel and lamprey, and without excretory duct: the spermatozoa or ova escaping by dehiscence of the cells and rupture of the peritoneal covering into the abdominal cavity, whence they are expelled by reciprocal pressure of the intertwined sexes from the peritoneal outlets of the cloaca. *Second,* the essential organ is divided into two, one on each side, and each has a simple duct. The two ducts however, usually, as in the Herring, coalesce into a single duct before reaching the urethra or cloaca; and the common duct is sometimes, as in the Sole, dilated into a saccular seminal reservoir. In the Salmon the parallelism is interrupted, the vasa deferentia being present but the ova escaping through the abdominal cavity and the peritoneal outlets. *Third,* the ducts of the two sides are separate (Sturgeon), but not separated from the ureter. The regurgitation of the urine into the sperm duct, or oviduct, being prevented by a valve; the oviduct is not continuous with the ovary. *Fourth,* testis or ovarium, each, with a long and complex duct, distinct from the ureter (Plagiostomes); the beginning of the vas deferens convoluted into an epididymis, and its end dilated into a seminal reservoir, with a plicated glandular inner surface; the oviduct not continuous with the ovarium and dilating into a receptacle or uterus, with a plicated surface, at its terminal half. In Batrachians the vas deferens is not separate from the ureter, and there is no intromittent organ. The parallelism between the male and female is broken by the fact that the oviducts, which are separate from the ovary, are separate also from the ureters, and have their proper openings in the cloaca. In Reptiles the conduits from the testes and kidneys, as well as the corresponding ducts in the female, are distinct to the cloaca and terminate there on separate papillæ.

A detailed account of the generative products and development

of Hæmatocrya terminates Vol. I., and proves that the author has not omitted the subject of development from his extensive range of study of the animal kingdom. The account does not differ much from that usually given. In the case of the eye and ear the author considers that the organs, the 'eyeball' and the 'acoustic labyrinth,' are not formed, as stated by most embryologists, from involutions of the external integument (the 'hornblatt' of the Germans), but by the infolding of 'superficial blastema,' which takes place to meet the production of the nerve-process from the cerebral centre. Thus the crystalline lens is formed (in this blastema) between the ends of the elongated and curved ophthalmic vesicle *beneath* the delicate tegumentary layer connecting them (p. 603); and when describing the development of these organs in birds, Vol. II. p. 262, he adds:

"It is a mistake to speak of the labyrinth or eyeball as being formed by the integument, or beginning as 'cutaneous follicles,' for the structures of the skin are not differentiated when they first appear; a layer of cellular or primitive blastemal tissue represents the integument, and a greater number of cells is aggregated at the points which tend inward to meet the productions from the nervous centres. After the essential organs of sense are established, then is the skin developed and modified more or less for their protection, forming the outer ear and the eyelids: but both passages are closed by transparent membranes, as 'ear-drum' and 'cornea.' Only in the case of the olfactory organ does the primitive depression retain its outlet, and in the bird and other air-breathers, it also communicates with the air-passage: having the tegument superadded and modified, in most, as external nostril and nose."

Whether he conceives the main neural axis to be also developed from the external integument lining the primitive dorsal groove, or in blastema formed beneath it, is not stated.

The section on birds is certainly not the strongest part of the work. As the fish seems to have attracted the most, so, apparently, the bird has received the least attention from the author. The classification needs careful revision. We are left at a loss whether the Cursors are to be retained as a separate group, or whether the Ostrich is to be ranked with the Bustard, the Didus and Pezophaps with the Columbaceous group of *Rasores*, and the Apteryx, Dinornis and Palapteryx with the Megapodial family of *Gallinæ*. In the 'locomotion' of birds hints might well have been taken from the able though popular exposition, by an eloquent and closely-observant Duke, recently given in 'Good Words.' The statement (Vol. II. p. 113.) that "birds float by the specific gravity of their body, arising from the extension of the air-cells and the lightness of the plumage," can scarcely have been seriously intended, and should not therefore have been left without qualification. It, as well as the remark by Sir John Herschel, in his 'Physical Geography,' p. 347, that the albatross sleeps on the wing, are refuted by Capt. F.

W. Hutton, who, in some interesting observations upon the flight of that bird in the 'Ibis' (July 1865), concludes that the bird cannot sustain itself in the air unless it has an onward movement, and shows that this movement is given by the wings. The same writer shows also that the air in the air-cells can have little effect in buoying the bird up, and regards their use to be to enable the bird to shift slightly its centre of gravity.

The chapter on the grouping of the class Mammalia is nearly a reprint of parts of the *Classification and Geographical distribution of Mammalia* published in 1859; and the author's fourfold primary division into the subclasses Archencephala, Gyrencephala, Lissencephala and Lyencephala, based upon the four leading modifications of cerebral structure in that class, was submitted to the Linnæan Society in 1857. It has, therefore, been for some time before the world; and we are, on the whole, inclined to accept it as a real improvement on its predecessors and as the best that has yet been suggested. A new classification is, we grant, *per se*, an evil, a vexation to older students, repulsive and a source of perplexity to beginners, and should not therefore, be introduced unless it presents distinctly counterbalancing advantages. Anatomists and amateurs have become accustomed to the Cuvierian divisions and are unwilling to relinquish them. Still it must be admitted that they do not satisfy the requirements of advanced science. The fact that the primary grouping by the unguiculate and ungulate features places the marsupials and monotremes, as well as the insectivora and rodents, above the elephant and the horse is enough to show that some alteration was needed, and prepares us to regard with favour an attempt at the redistribution of the class by one whose long-continued preparation so well fitted him for the task.

In reference to the selection of the brain as the basis for a classification, it may be urged that it is an organ ill chosen for the purpose, because, *first*, its leading differences in Mammalia are modifications only, that is, differences in degree rather than in kind. Thus, the drawing of the brain of the Lemur (p. 271), which is placed high among 'Gyrencephala,' shows that a somewhat greater extension only of the cerebrum forwards and backwards constitutes the difference between it and the brain of the Agouti, of which a drawing is given (p. 270) as the representative of the subordinate 'Lissencephala.' *Secondly*, the relations of the brain, of those parts more particularly—the cerebral and cerebellar hemispheres—upon which the classification is founded, to the rest of the body are not clearly known. Even the relations to psychical endowment, to external form, and to variety of movement, present some striking anomalies. Thus the brain of the Porpoise, which is placed lowest among 'Gyrencephala,' is relatively

larger and more folded than that of any of its companions in the subclass. Difficulties and anomalies of this sort will, however, present themselves in any system of classification. Nature has held herself free to modify her own great plan, so as best to suit the infinitely varied conditions of her numerous progeny. The order which she exhibits ever lures us on to greater refinement in the classification of her products, while the variety of her modifications ever baffles our attempts at exactness and completeness. A faultless and unexceptionable classification, therefore, we must not expect in this or any part of the division of Natural History. We must be content to accept that which has the fewest faults, and which seems to throw the genera into the most natural order; and the Owenian classification by the cerebral method, in our opinion, fulfils these requirements better than any other which has been presented to us. It is a decided improvement on Cuvier's arrangement, and is to be preferred to the placental method of Milne Edwards which has recently been advocated by Professor Huxley. It has at any rate the advantage of more easy and extensive application than the latter. The placenta can be examined only at certain periods and in one sex. It does not exist even throughout mammalia, so that the basis of classification has to be shifted in the aplacentals from the connection between the mother and the offspring to the genital organs of the former. But the great objection to the placental method is that the peculiarities in the structure and shape of the placenta, in different classes of animals, do not seem to be associated with sufficiently distinctive features in the rest of their structure to render it a satisfactory guide in the attempt to group them. Thus the discoidal deciduous placenta is common to man as well as to Rodentia, Insectivora, and Cheiroptera; the zonular placenta is present in the Elephant as well as in the Carnivora; and in most Pachyderms, in Solipeds, and Cetacea the placenta is non-deciduous and diffuse.

We further agree with Prof. Owen in thinking that the numerous and important features that distinguish man from his nearest approach are a sufficient ground for elevating him into a separate sub-class. The importance of the posterior cornu and the hippocampus minor fades into insignificance in comparison with that of the large size, rounded form, and well-folded surface of his brain; while the capacity for intellectual endowment and knowledge that genders responsibility, the communication of ideas by language, and the power of handing down accumulated stores of information from generation to generation, the firmly-planted foot, and the power of the hand to wield all nature to his service, mark man off from the rest of creation by a wider interval, we had almost said, than separates any two members lower down in the animal scale.

THE PHYSIOLOGICAL ANATOMY AND PHYSIOLOGY OF MAN, by ROBERT B. TODD, WILLIAM BOWMAN, and LIONEL S. BEALE. A new Edition by the last-named Author, Part I. 8vo. 7*s.* 6*d.* LONGMAN & CO. 1866.

THE three names on the title-page of this work are among the foremost in the annals of British physiology. To Dr Todd we owe, besides important articles on the nervous system and other subjects communicated by himself, the *Cyclopædia of Anatomy*, a work that has done more than any other work of our time to advance anatomy and physiology and to uphold the character of British anatomists and physiologists. Mr Bowman's papers on the minute anatomy of muscle and of the kidney have perhaps never been surpassed in the correct and original observation, the clearness of description, and the comprehensiveness of view which they evince. They have stood the test of many years of keen examination, aided by improvements in the means of investigation, without shewing a flaw; and we cannot but regret, on behalf of our science, that the more engrossing avocations of practical life have withdrawn so able an investigator and lucid an expounder from the quiet path of physiological study. King's College was fortunate in obtaining two such occupants of the chair of physiology; and it has been no less fortunate in their successor. As an assiduous worker, and a patient, profound, successful investigator of minute structure Dr Beale has no equal in this country. He alone takes a place worthy of the British name beside the histologists of Germany; and he alone has been able to bring the highest produced powers of the microscope to a satisfactory bearing upon animal structure. He is not merely a physiological anatomist but also a physiologist, and therefore peculiarly qualified to prepare a new edition of the original and admirable work of Dr Todd and Mr Bowman. It appears from the short preface that he had already assisted those authors in the completion of the concluding part of their second volume; but for the work in its new form he is alone responsible. "The present part, consisting of the *Introduction*, Chapter I. on *Structure*, and Chapter II. on *Chemical Composition*, is complete in itself. In the further prosecution of the work, the original plan will be adhered to as closely as possible, but the text will be modified where necessary, and numerous new figures introduced."

In the interval of twenty years which has elapsed since the first appearance of the work, physiology has made much progress, especially by the more full application to it of the light which has been derived from the other physical sciences. It has accordingly been necessary to add a great deal of new matter; and this has

been well and fairly done, the new being skilfully welded with the old. We have a succinct and clear account of Professor Graham's researches in *Osmosis* and the *Colloid state*, of Pasteur's experiments on *fermentation* and *putrefaction*, of the *correlation of forces* and the *relation of Physical Forces, Vital Power*, &c. With regard to the latter subjects Dr Beale conceives that the correlation between *vital* and *physical* forces holds good only in respect to those which are really physical forces manifested in living beings. The self-constructing, self-maintaining and self-propagating power is referred to a something which seems totally distinct from ordinary force, and which may be termed *vital power*. This seems to be pretty much the view taken by most physiologists. The difficulty is to determine the range of the vital power, its limits being much more restricted by some physiologists than by others.

With reference to Mr Darwin's view the editor says:

"Looking at the facts broadly and generally, there undoubtedly seems much in its favour, but when we come to consider the structural changes which must occur in a single organ of one of the higher animals, it is more difficult to accept his conclusion......the anatomical differences between corresponding tissues of closely allied species are often so distinct that the anatomist familiar with them could distinguish one from the other. For example 'there is a recognisable difference between the unstriped muscular fibres of the bladder of the hyla, of the common frog, and of the newt. So with regard to the chemical composition of the corresponding solid matters, fluids, &c. of closely allied animals, remarkable differences may be demonstrated.' Such differences, affecting the minute structure and chemical composition of every part of the organism of creatures closely allied, are strong arguments in favour of the doctrine of the independent origin of distinct species." p. 40.

Professor Beale's views on cells and the formation of tissues from them differ, as is well known, in many respects, from those usually entertained. Instead of regarding the cell to be necessarily composed of *cell-wall, cell-contents* and *nucleus*, he describes it as a more minute 'mass of germinal matter,' separated from other similar contiguous masses by 'a little soft formed matter' which

"is changed into a soft, passive, transparent homogeneous substance, exhibiting a membranous character (cell-wall), this henceforth protects the matter within, and, at the same time, being permeable to fluids, nutrient matter passes through it into the interior and undergoes conversion into living matter, which thus increases." p. 77.

We must confess that we have never felt satisfied with the reasons the author gives for the view, which he so positively maintains, that "the formed material of which the envelope is composed results from the death of the living matter," and that the interior of the cell (the nucleus) is alone "living germinal matter" and "concerned in the active changes that take place;" that "the formed

matter has ceased to live and can never again acquire the properties it has lost." The internal germinal part passes, as he affirms, uninterruptedly into the external formed part; and it is rather a fine distinction to speak of the one as living and active, and of the other as dead and powerless; especially when we observe that changes are taking place in the external membrane or formed part, changes which, even in the different varieties of epithelium, do not seem to be sufficiently explained by the operation of external influences. In most cells, too, an enlargement takes place throughout the whole thickness of the cell-wall, which appears to indicate a process of interstitial increase, or growth, rather than a mere distension of the outer part by addition from within. Moreover, if we understand Dr Beale's views aright, some of the active functions, such as muscular contraction and nervous influence, are effected by means of the formed material. We can understand that certain of the important processes, such as those of appropriation and conversion of the nutritious materials, imbibed by the cell, may take place in the internal germinal part, and in this respect each cell would resemble an entire animal; but we are unwilling to admit that the exterior of the cell possesses none of the vital properties and is a mere passive, lifeless agent, and that indeed a large part—perhaps the larger part—of our bodies, being composed of cell-walls, is in this condition. Some more cogent reasons than are adduced for such a view are needed for its acceptance. It seems also to be opposed to the multiplication of cells by division, a process which Dr Beale admits; though his description of the mode in which it takes place is not quite clear.

The nuclei and nucleoli are held to be by no means essential features in the cells nor, indeed, always present. They

"are but new living centres appearing in preexisting centres, and they may be supposed to mark off another series of changes in the matter in which they appear, differing perhaps in some minor particulars from the first changes which occurred." "They are always more intensely coloured with alkaline colouring matters than other parts of the living or germinal matter, a fact which is alone sufficient to shew the difference between a true nucleolus or centre and an oil globule, which has often been wrongly termed a nucleolus." p. 88.

In the development of tubes and fibres from cells Dr Beale maintains that there is not, as usually stated, a shooting out of processes from the cells, which meet those of other cells and unite, but

"The masses of germinal matter are continuous with one another; so that, in fact, the connecting processes or tubes are connected from the first, and, as growth takes place, the connecting tubes become thinner and thinner, being as it were gradually drawn out as the masses of germinal

matter become separated farther and farther from one another." p. 76. "These cells and tubes," speaking of the structure upon the surface of a tooth, "do not, however, constitute an elaborate system of channels for the distribution of nutrient material to the tissue which intervenes between them, as Virchow and his school maintain." p. 84.

Although we are not prepared fully to admit Dr Beale's views on the difference between the 'germinal' and the 'formed matter' of cells, we have no doubt that process of cell-growth required a careful reinvestigation under the higher microscopical powers and other improved methods of examination which Dr Beale has been able to apply to it, and we shall be glad to find the results which he has obtained receive the confirmation of other careful workers in the same field.

Atlas der Gehörorganges, von Dr Rüdinger, Part I. small folio, 15*s*. Dr Rüdinger is prosector of Anatomy at Munich, and in this Atlas he has furnished an additional example to that previously rendered by him in his very beautiful series of photographs of the nervous system of the application of the photographic art to the illustration of anatomy. The photographs in this Atlas of the ossicles of the exterior and interior of the osseous labyrinth, &c. are very good, and the description in the letter-press is full; but there is nothing new of importance.

Anleitung zu den Präparirübungen und zur Repetition der descriptiven Anatomie des Menschen, von Julius Budge, Professor der Anatomie und Physiologie, Director des anatomischen und zoologischen Museums der Universität Greifswald. Erste Abtheilung fur die Präparantem im ersten Semester. Bonn, bei Adolphus Marcus, 1866.

This dissector's guide for first-year's students, emanating from so able a man as Professor Budge, is calculated to maintain the reputation of the German schools for the teaching of practical anatomy. The Professor recommends that the dissection of the subject should commence with the posterior surface; and it would be well, as is indeed the practice in the Dissecting Rooms in the University of Edinburgh, to follow this advice sometimes, as parts which are now often carelessly dissected, in consequence of their not being approached till decomposition has set in, would then receive more attention. He finds the best preserving fluid to be a mixture of half a pound of sulphuric acid, two-thirds of a quart of water, and one-tenth of a quart of acetic acid thrown into the arteries, but even this has the disadvantages of destroying colour and rendering the muscles somewhat brittle.

Tapeworms; their Sources, Nature, and Treatment, by Spencer Cobbold, M.D. F.R.S. Longmans, 1866. This little book is practical in its character, not intended to supersede the author's larger treatise on Entozoa, and does not contain any thing of anatomical interest beyond what has been already communicated by him. In an appendix he refutes the prevalent notion that the pig is the most fertile source of human entozoa, and shews that the *Tænia mediocanellata*, which is the most frequent infester of man, is commonly derived from eating beef.

REPORT ON THE PROGRESS OF ANATOMY, *from 1st January to 1st July*, 1866, *by* WM. TURNER, M.B.

OBSERVATIONS on the CONNECTIVE SUBSTANCE, and the process of ossification which occurs in it, are related by Leonard Landois (Siebold and Kölliker's *Zeitschrift*, 1st Part, 1866). He supports the view that the embryonic connective tissue is a mass of protoplasm with nuclei imbedded in it. In the course of development the protoplasma lying next the nuclei differentiates from the peripheral portion; it sends out processes which vary in number, and form sometimes a spindle-like, at others a star-like connective tissue corpuscle; these processes anastomose, and form a cell network, which possesses, however, no cell-wall. In the meshes of this cell network lies the peripheral part of the protoplasm, which forms the basis, substance, or "parietal substance," as Remak named it. This parietal substance may persist as a gelatinous, structureless material, as in the mucous tissue found in the umbilical cord and vitreous humour, or it may undergo fibrillation, as in the ligaments, tendons, and other denser forms of connective tissue. The author's observations on ossification were made on the tendons of birds. He holds, with Virchow, that the anastomosing corpuscles of the connective tissue become converted into anastomosing bone-corpuscles, the nucleus of the one becoming the nucleus of the other, whilst the fibrillated 'parietal substance' is impregnated with calcareous salts.

BILE-DUCTS. The recent observations of Mac-Gillavry on the arrangement of the finest bile-ducts in the lobules of the liver (*Sitzberichte der Kais. Akad. der Wissenschaft in Wien*, Bd. 50) have caused renewed attention to be directed to this subject. Irminger and Frey (*Siebold u. Kölliker's Zeitschrift*, 2nd Part, 1866) have made numerous injections, and have obtained the most satisfactory results in the liver of the rabbit. They, more or less, completely filled a close network of fine gall-duct capillaries, which reached from the interlobular ducts to the centre of the lobule, and the meshes of which wound around the individual liver-cells. Under a high magnifying power this network was seen to be very regular, without varicosities, with sharp contours, and distinct from the venous and lymphatic plexuses which are also present in the lobules. Additional evidence in favour of the opinion that the bile-duct capillaries are situated between the liver-cells is advanced by Oskar Wyss (*Virchow's Archiv*, April, 1866), who in the examination of icteric livers observed that the very finest BILE-DUCTS were distended with bile in various places within the hepatic lobules. He examined their relations to the liver-cells, and found that they formed a network, in the meshes of which the liver-cells were situated. But the most curious observations on this subject have been contributed by Chrzonszczewsky (*Virchow's Archiv*, Jan. 1866). His preparations were made by a new method, by what he calls a natural physiological injection. This consists in administering to a living animal a coloured solution, which being excreted by a certain organ or organs, tints the fine ducts or tubes along which its colouring matter proceeds in its outward passage. He has found that the substance known in commerce as indigo-carmine, the sulphindigotate of soda, may be administered to an animal either by direct injection into the blood, or by the stomach. If the dose be repeated three times within an hour and a half the urine and bile are both coloured, and if the animal then be killed, and the organs placed in absolute alcohol or chloride of potassium, the colouring matter is precipitated in the organs as a finely granular deposit. Lobules of the liver, examined according to this mode of preparation, exhibit a fine unbroken network of gall-duct capillaries

filled with indigo-carmine. They are mostly of uniform diameter and without varicosities. They are quite independent of the blood-vessels, lie between the liver-cells which they enclose within their polygonal meshes, a single cell as a rule lying in each mesh. At the periphery of the lobule, and partly also around the vena centralis, this network becomes continuous with the larger ducts. All their characters indicate the presence of a membrana propria for these ducts.

Henlè in the preface to the last part of his comprehensive *Handbuch der systematischen Anatomie des Menschen*, 1866, Göttingen, admits that he was in error in describing two independent sets of TUBULI URINIFERI in the kidney. He now agrees with Schweigger-Seidel that a convoluted wide canal acts as the medium of communication between the ascending part of the "looped" uriniferous tube and the beginning of larger tubes formed by the union of those which are more minute. Hence the tubes which open at the apices of the pyramids are continuous with those which proceed from the Malpighian capsules.

Julius Arnold (*Virchow's Archiv*, Jan. 1866) relates his observations on the minute structure and chemistry of the SUPRA-RENAL CAPSULES. He subdivides the cortical part of the capsule into three zones, which he names zona glomerulosa, fasciculata, and reticularis. The entire cortex is built up of interstitial connective tissue and parenchyma corpuscles, which are differently arranged in the different subdivisions of the cortex. In the zona glomerulosa the interstitial connective tissue limits roundish spaces, the interior of which is traversed by a reticulum, in the meshes of which lie roundish, nucleated parenchyma corpuscles. Owing to the connective tissue in the zona fasciculata being arranged in a longitudinal direction, this subdivision presents a columnar-like appearance. Between these columns the reticulum and the parenchyma corpuscles are situated. The zona reticularis consists of a network of connective tissue symmetrically arranged, in the meshes of which the parenchyma corpuscles are enclosed. The medullary part of the supra-renal capsule consists of interstitial tissue and parenchyma corpuscles. The interstitial tissue bounds longish oval spaces in the peripheral part of the medulla, which are arranged in two rows, one over the other, and lie with their long axes perpendicular towards the central vein. These spaces are subdivided into still smaller parts by a delicate reticulum, in which large nuclei with the portions of protoplasma belonging to them are situated. In the central part of the medulla the interstitial tissue forms a net with small meshes, containing the parenchyma corpuscles.

The blood-vessels of the zona glomerulosa are arranged in the form of glomeruli, which correspond to the spaces already described in this part of the cortex. The vessels of the zona fasciculata extend at tolerably regular intervals from each other, in a radiated manner, from the periphery towards the medulla. They lie in the connective tissue which marks out the columnar arrangement of this zone, of which they form important constituents. In the zona reticularis the vessels form a very fine network, the meshes of which contain the parenchyma bodies. The general course of the vessels in the cortical substance is as follows: from the glomeruli situated in the outer part of the cortex tolerably wide vessels proceed, which traverse the zona fasciculata in a radiated manner, and then, by subdivision of these and reunion, the fine vascular network of the zona reticularis is produced. The vessels of the medulla arise out of the capillary network of the zona reticularis as fine venous roots, which at first lie parallel to the outer surface of the supra-renal capsule, and then extend towards the central vein. Between these veins sinus-like spaces are inter-

calated, which, like the vessels, possess a homogeneous and very delicate wall. Arteries and veins occur in the central part of the medulla; the former spring from the arteries already described in the cortex, form a network in the medulla, from which veins arise and pour their blood into the central vein. The arteries which carry blood to the capsule are from fifteen to twenty in number, and from their very complete distribution within the organ it must be regarded as one of the most vascular of organs. The paper concludes with some observations on the chemistry of the capsules.

[The description of the cortical part and the distribution of the blood-vessels correspond, therefore, on the whole, with that given by Kölliker: but the views of Kölliker and Leydig as to the nerve-ganglionic nature of the corpuscles contained in the medullary parts are not confirmed by Arnold.]

Chrzonszczewsky (*Virchow's Archiv,* Jan. 1866) furnishes additional observations on the much disputed question as to the existence of an EPITHELIAL LINING TO THE AIR-VESICLES OF THE LUNGS. He examined the lungs in the frog, the blindworm and the coluber natrix. In each alveolus he found a complete, uninterrupted, tesselated epithelium covering the capillaries.

Eberth (*Virchow's Archiv,* March, 1866) relates some observations made on the intimate structure of the CILIATED EPITHELIUM after acting on the cells with very dilute acetic acid and aniline. He finds within the cells a delicate longitudinal striation. The striæ are formed of a finely granular substance; they do not lie on the same plane, but are formed of the cell protoplasma, and are prolonged into the cilia themselves. He is not quite clear how they are related to the nucleus of the cell.

Chrzonszczewsky (*Virchow's Archiv,* Jan. 1866) advocates the view that the finer LYMPH-VESSELS take their rise from the anastomosing processes of the corpuscles of the connective tissue. His observations were made on the peritoneal coat of fowls whose ureters had been tied some hours before death. He found that when the delicate serous membrane was examined in glycerine, the connective tissue corpuscles were filled with a finely granular mass of urates and that the lymph-vessels were also filled with the same material. The union of the processes of the connective tissue corpuscles with the lymph vessels could be distinctly seen. That the granular contents of the corpuscles and lymph-vessels were really urates was proved by the well-known reaction with nitric acid and ammonia. The author concludes from these experiments that the urates arise in the connective tissue and are carried away from it by the lymph-vessels.

Chrzonszczewsky (*Virchow's Archiv,* Jan. 1866) describes his researches into the structure of the CAPILLARY BLOOD-VESSELS. He states that the walls of the capillaries consist of two layers, a structureless membrane and an epithelial layer, that the epithelium of the capillaries is flat and spindle like, whilst that of the small arteries and veins is polygonal, between which transitional forms lie: that the well-known nuclei of the capillaries are the nuclei of their epithelial lining.

OBSERVATIONS ON THE STRUCTURE OF THE CORD OF THE SYMPATHETIC. By L. G. COURVOISER (*Schultze's Archiv,* II. 13—45).

E. BISCHOFF has recently made a minute examination of the ANASTOMOSES OF THE CRANIAL NERVES (*Gekröate Preischrift,* München and *Centralblatt,* Feb. 1866).—The following are some of his principal conclusions. There are no anastomoses between the three chief nerves of special sense

and other nerves, that between the auditory and facial through the portio intermedia is only apparent. The chorda tympani, by far the largest part of which is a branch of the facial, is also connected with the otic ganglion, from which indeed fibres running both peripherally and centrally pass into the chorda tympani. The auricular branch of the vagus is very variable; it may be absent, but mostly arises from the vagus and glosso-pharyngeal, and very commonly branches proceed from it which join the facial. The Jacobsonian anastomosis between the otic and petrous ganglions and the plexus on the internal carotid is a true plexus, and the nerves derived from it for the Eustachian tube proceed from all three sources. He constantly found a microscopic ganglion on the nerve proceeding from the lesser superficial petrosal to the fenestra ovalis, and denies the existence of the usually described anastomotic branch between the lesser petrosal nerve and the knee-shaped bend of the facial; with Beck he regards this supposed branch as a small artery. He holds it to be impossible to separate the accessory and vagus in the jugular foramen whilst the anastomosis between the vagus and hypoglossal is only apparent.

AN ANASTOMOSIS BETWEEN CENTRAL GANGLION-CELLS. By L. Besser (*Virchow's Archiv*, May, 1866).

A systematic description of the mode of arrangement of the CONVOLUTIONS OF THE HUMAN CEREBRUM is given by W. Turner (*Edinburgh Medical Journal*, June, 1866, republished, with additions, as a pamphlet). In this essay are incorporated the results of the most recent inquiries into the arrangement of the convoluted surface of the hemisphere, which have proved that the gyri, instead of being without order or method, possess precise morphological positions and relations. Attention is drawn to the importance of studying the arrangement of the convolutions in connection with the physiology and pathology of the cerebrum.

On the WEIGHT OF THE BRAIN and the circumstances affecting it. By John Thurnam (*Journal of Mental Science*, April, 1866). In this paper, which is illustrated by numerous tables, the author discusses the influence which sex, age, weight and stature of the body, ethnological characteristics and race, social position and education and disease, particularly insanity and idiocy, exert on the average weight of the brain.

Bochdalek (*Prager Vierteljahrschrift*, 1st Part, 1866) relates a case in which external OSSIFICATION of the AURICULA of the left EAR, and traces of ossification in the upper part of the right anti-helix were observed; and a preparation in which there was congenital defect of the membrana TYMPANI.

Niemetschek (*Prager Vierteljahrschrift*, 1st Part, 1866) describes a fine capillary network in the MACULA LUTEA of the RETINA, which is often described as non-vascular. His injections were made in the eyes both of children and adults.

The Anatomy of the FOVEA CENTRALIS of the Human Retina is described by J. W. Hulke (*Proc. Roy. Soc. London*, June 14, 1866). The fovea is a minute circular pit in the inner surface of the retina, its edge is the most raised part in the macula lutea where the retina is thickest, its centre the most depressed part where the retina is thinnest. At the centre of the fovea the structures from without inwards are as follows: bacillary layer and outer limiting membrane, a little finely areolated connective tissue, the inner granule-layer and ganglionic layer very attenuated, a thin granular band containing optic nerve fibres and the internal limitary membrane. The arrangement of these structures is then

detailed and various deductions as to the physiology of the part are based on these structural differences.

An elaborate paper on the Anatomy and Physiology of the Retina is given by Max Scultze (*Archiv f. Microsk. Anat.* Bd. 2). Prof. Scultze, who has already contributed so much to our knowledge of this difficult piece of anatomy, employs perosmic acid, which he finds a material particularly useful for bringing out the characters of the retina. The 'cones' and 'bacilli' forming the outer sheet of the retina (Jacob's membrane) are found to present a close resemblance to nerve-fibres and are judged to be the perceptive elements; the light passing through them and being reflected back upon them from their outer or peripheral parts which differ from the rest in structure. The cones (Zapfen) are alone present in the axial or yellow spot of man and apes; but over the rest of the retina the bacilli (Stäbeben) exist in greater proportion than the cones, surrounding them, so that two or three bacilli are placed between every two cones. In animals moving about in twilight or gloom, as owls, bats, moles and hedgehogs, there are no cones; whence it is inferred that the latter are perceptive of the quality or colour and the bacilli of the quantity of light. In Birds (owls excepted) the cones preponderate over the bacilli, reversing the relative proportions that are found in man and most mammals; and they have, in the outer part of the inner division of each, a circular spot or nucleus which, in most instances, is of yellow, or red, or deep ruby colour. Among Reptiles, the chelonians resemble birds; lizards and serpents have only cones, some presenting the yellow pigment spots like those of birds. In Amphibia the bacilli are large and thick, the cones small with a faint yellow or colourless spot in each. Osseous fishes have cones and bacilli like ordinary mammals. Rays and sharks, however, resemble bats and owls in being devoid of cones. Many other points are discussed—the structure of the outer layer of the retina, its development, &c.; indeed it is a very elaborate valuable paper and copiously illustrated.

Bochdalek (*Prager Vierteljahrschrift*, 2nd Part, 1866) describes various modifications in the arrangement of the LACHRYMAL APPARATUS: increase in number of the puncta lachrymalia, and lachrymal ducts; variations in their size and in the mode of opening of the ducts into the lachrymal sac; modifications in the form and structure of the sac itself, and of the nasal duct proceeding from it.

MUSCULUS TRITICEO-GLOSSUS. Bochdalek junr. (*Prager Vierteljahrschrift*, 2nd Part, 1866) describes a muscle hitherto entirely overlooked, except a brief statement in Henlè's Anatomy, which arises from the nodule of cartilage (corpus triticeum) in the posterior thyro-hyoid ligament, and passes forwards and upwards to enter the tongue along with the Kerato-glossus muscle. He met with this muscle eight times in twenty-two subjects. It occurred in both sexes, sometimes on both sides, at others on one only.

J. B. Pettigrew gives the following results at which he has arrived by his exquisite dissections of the MUSCULAR FIBRES of the BLADDER and PROSTATE (*Proc. Royal Soc.* xv. 244). The muscular fibres of the bladder are arranged spirally, forming figure-of-8 loops, the superficial more longitudinal or drawn out, the deeper more circular or flattened. They are in four sets—an anterior and posterior, and a right and left lateral; the latter accessory and less fully developed. The fibres are arranged in seven strata, three external, three internal, and a middle, pursuing well-marked directions in each. The external and the internal are the most oblique; their obliquity diminishes towards the central stratum, which is formed by the blending of

their terminal or transverse portions. A close analogy is thus traced between the disposition of the muscular fibres of the bladder and those of the heart, as described by Pettigrew in *Philos. Trans.* 1864; and he hints at similar structure in the stomach and uterus.

Hermann Meyer (*Virchow's Archiv*, February, 1866) contributes an important memoir on the mechanism of SKOLIOSIS.

1st. He distinguishes pure skoliosis from its complications.

2nd. Pure skoliosis is very rare, and appears only to arise in the forward stoop of old people.

3rd. The complex form is the most common; it takes its rise during childhood, and is chiefly found in the dorsal vertebræ, and in this latter form the pure skoliosis is associated with lordosis and a spiral twisting of the vertebral column.

4th. The complex lordosis is, according to its degree, either relative or absolute; but if the lumbar region is also skoliotic, then a relative or absolute kyphosis occurs.

5th. The spiral twisting, as such, is not an independent movement, but is only the expression of a stronger outward movement of the bodies of the vertebræ.

6th. Lordosis is also a form of the more marked outward bulging of the bodies of the vertebræ. It may therefore partly replace the spiral twisting, and *vice versâ.*

7th. The skoliotic form of the thorax is a consequence of the spiral curvature.

8th. This arises partly from change of position, and partly from change of form of the ribs.

9th. These changes are due to the individual action of the three factors working to produce complex skoliosis, viz. skoliosis, lordosis, and spiral twisting.

10th. The unsymmetrical form of the vertebræ involved in skoliosis is chiefly due to the reaction of the ribs. The direction of the spinous processes is moreover modified by the traction of the muscles, and the form of the body by the outward bulging of its osseous centre.

On the HISTOLOGY OF THE ARTICULAR SURFACES AND CAPSULES, with critical remarks on the 'silver process.' By C. Hueter (*Virchow's Archiv*, May, 1866).

On certain points in the MORPHOLOGY OF CLEFT PALATE. By John Smith (*Proc. Roy. Soc. Edinburgh*, Feb. 19, 1866). The observations of Engel, on children born with a cleft in the hard palate, show that the maxillary bones are not only ununited, but more widely separated from each other than in the natural condition. From the measurements of sixteen cases of cleft palate in the adult the author has observed that the transverse distance between the palatal sides of the upper pair of anterior bicuspids is considerably less than in a well-formed jaw. Hence, whilst in the infant with cleft palate there is abnormal *separation*, in the adult there is abnormal *approximation* of the parts on each side of the fissure.

Säxinger (*Prager Vierteljahrschrift*, 1st Part, 1866) describes several cases of CONGENITAL MALFORMATION OF THE UTERUS: viz. a case of uterus unicornis of the left side, which had a cord-like right rudimentary horn connected to it close to the orificium internum; both ovaries were large, and in the left a true corpus luteum was situated. A case of uterus bicornis in which the horns, symmetrically developed, were separated by a partition

extending half way down the cavity, but the lower half and the cervix had no septum. The vagina close to the external os was simple, but for the rest of its extent was separated into two parts by a septum. The right half of the vagina had at its orifice no hymen, but a distinct circular one existed on the right side. A case of uterus fœtalis in a woman aged 51, where the ovaries were completely absent; and some cases of atresia vaginæ.

W. Turner (*Edinburgh Medical Journal*, May, 1866) relates two cases of Uterus Bicornis unicollis in each of which the left horn was rudimentary, and no communication could be found between its cavity and the canal of the cervix or vagina. In both cases the left horn was pregnant. The author discusses the mode in which impregnation was effected, and considers it is probable, the direct passage of the semen being prevented, that the spermatozoa passed through the horn and tube of the right side into the mouth of the left tube, down which they proceeded into the rudimentary left horn.

Spaeth (*Central-blatt*, Feb. 1866) describes a case of Uterus biloculаris in which a fœtus occurred in the right half of the uterus. The tubes on both sides were permeable. The corpus luteum was in the left ovary.

W. M. Banks (*Glasgow Medical Journal*, June and July, 1866) gives a *resumè* of the most recent observations 'On the development of the Generative System.' He incorporates in it an account of his own researches, which formed the subject of his Prize Thesis, published in Edinburgh in 1864.

A. P. D. Handyside (*Edin. Med. Journal*, March, 1866) gives an account of the Arrested Twin Development of Jean Battista Dos Santos, which has already been described by Wm. Acton (*Lond. Med. Ch. Tr.* xxix.), and Ernest Hart (*Lancet*, July 29, 1865). There is a double penis, each perfect and large; also a double scrotum, each scrotum containing a large testicle in its outer compartment, the testicle, believed to have existed in the internal compartment, having, it is said, retired into the abdomen in boyhood. A middle lower limb hangs from behind the scrotum, connected arthrodially with a process projecting from the pelvis, and is double in many of its parts —a representative, in short, of two limbs.

Abnormal Size of the Parietal Foramina. Wrany (*Prager Vierteljahrschrift*, 2nd Part, 1866) describes four crania in which the parietal foramina were unusually large. In the first the left foramen was large enough to transmit a raven's quill, the right was somewhat smaller. In the second these foramina were oval, the left being nearly one-fourth of an inch long by one-twelfth broad, the right nearly half an inch long by one-fifth broad. Furrows in the bones for branches of the meningeal artery proceeded to these foramina. In the third, oval parietal foramina existed, of which the right measured nearly three-eighths by one-fourth of an inch, the left nearly one-third long by somewhat less than one-fourth of an inch broad. Vascular furrows also proceeded to them. In the fourth, four-fifths of an inch from the posterior border of the parietal bones, two round foramina occurred, which were united by a fine fissure running through the sagittal suture. The right foramen measured four-fifths of an inch, the left about three-fifths. Distinct arterial furrows proceeded to the margins of these openings. In all the cases the part of the sagittal suture lying between the enlarged parietal foramina was obliterated. Wrany considers that the large size of these openings is correlated with an enlarged condition of the perforating branches of the meningeal arteries, and compares his

specimens with one previously described by W. Turner in the *Edinburgh Medical Journal*, August, 1865.

H. Welcker of Halle contributes to the newly established German anthropological journal (*Archiv für Anthropologie*, Heft I. 1866) an elaborate CRANIOLOGICAL MEMOIR, in which he describes his method of depicting and measuring crania, and his mode of determining the age and sex of a skull. He discusses also brachycephalism and dolico-cephalism more especially amongst the Germans, and the relation between the breadth and height of crania.

W. Ebstein (*Reichert and Du Bois Reymond's Archiv*, Part 2, 1866) describes a case of CONGENITAL INSUFFICIENCY of the TRICUSPID VALVE, conjoined with absence of the Thebesian valve, and a patent condition of the foramen ovale, and W. Gruber (*Reichert and Du Bois Reymond's Archiv*, Part 2, 1866) relates two additional cases to the one previously recorded by him in the same Journal, in which the VENA HEMIAZYGA OPENED INTO THE RIGHT ATRIUM OF THE HEART.

REPORT ON THE PROGRESS OF PHYSIOLOGY, *from 1st January to 1st July*, 1866, *by* WILLIAM RUTHERFORD, M.D., *Assistant to the Professor of the Institutes of Medicine, Edinburgh.*

ACTIONS OF POISONS.

PELIKAN (*Comptes Rendus*, No. v. 1866) has found that NERIUM OLEANDER is a true cardiac poison, and not, as Orfila supposed, an acrid narcotic. In frogs he observed that the first symptom produced by the poison was increased rapidity of the heart's action. After some minutes the rapidity diminished, the action became irregular, and the heart soon stopped in a state of complete relaxation. Contraction could be produced by an electrical stimulus. With other cardiac poisons the heart stops in a state of contraction. Stoppage of the heart in diastole is exactly what occurs when the vagus is strongly irritated.

Dr Brunton (*Edinburgh Prize Thesis*, 1866), in a most excellent Graduation Thesis upon DIGITALINE gives the following as the results of his experiments. It acts as a diuretic even in health. Poisonous doses first occasion diminished frequency but increased strength of the cardiac pulsations, together with contraction of the capillaries. The slackening of the heart's speed is due to the direct action of poison upon the heart, and not to the increased resistance offered by the contracted capillaries. After a short time the pulse becomes irregular, the capillaries dilate, the arterial tension diminishes, and syncope is apt to supervene. Lastly, the pulse becomes very rapid, and stoppage of the heart in a state of contraction soon follows.

The following conclusions relative to the action of ACONITINE have been arrived at by Dr Achscharumow (*Reichert and Du Bois Reymond's Archives*, No. 2, 1866). 1st. Death is not due to paralysis of the respiratory muscles, but to stoppage of the heart from paralysis of its motor ganglia. 2nd. The first effect is irritation of the medulla oblongata, which is communicated to the vagi. 3rd. Paralysis of the vagi supervenes, from continued irritation. 4th. The temperature and blood-pressure are lowered. 5th. The peripheral nerve-endings and trunks are entirely paralysed. 6th. Reflex function of the spinal cord remains intact. 7th. The brain is unaffected. 8th. It has no local action on the pupil.

The action of CARBONIC OXIDE has been investigated by Pokrowsky, of St Petersburg (*Reichert and Du Bois Reymond's Arch.* No. 1, 1866), and Traube (Abstract in *Centralblatt*, No. 10, 1866). According to Pokrowsky poisoning by carbonic oxide produces symptoms of suffocation, identical with those due to poisoning with hydrogen, nitrogen, or carbonic acid. He registered the changes in the circulation by means of Fick's (of Zurich) chymographion, and found, from experiments upon dogs, that the symptoms are in all essential points identical with those produced by the inhalation of hydrogen and carbonic acid. The symptoms occur in the following order: acceleration of pulse and increase of blood-pressure, restlessness, dyspnœa, spasms, retardation of the pulse with diminished blood-pressure and specific warmth, exopthalmos and dilatation of the pupil, cessation of respiratory movements, and, finally, stoppage of the heart's action; the systole becoming weaker and weaker, and the diastole more and more prolonged. The increased cardiac action in the first stage he refers to irritation of the cardiac centre in the upper part of the spinal cord (von Bezold), and the diminished action, to irritation of the vagi. He supports the theory that carbonic oxide enters into combination with the hæmo-

globin, and thereby renders it incapable of conveying oxygen to the tissues. With the above, the conclusions arrived at by Traube generally agree, but he ascribes the increased cardiac action to irritation of the sympathetic, for it occurred notwithstanding destruction of the cerebro-spinal centres.

Hermann, of Berlin (*Reichert and Du Bois Reymond's Archives*, No. 1, 1866), has been investigating the effect of ANÆSTHETICS upon the blood. He finds that chloroform, ether, alcohol, chlorocarbon, amyl, chlorethyl and its chlorine substitutes, ethyl, methyl, and amyl alcohols, nitrous oxyde and olefiant gas, all possess a property hitherto ascribed to ether and chloroform only; they dissolve the blood-corpuscles, leaving behind a colourless viscous granule representing the corpuscle. This is ascribed by Hermann to the action of the anæsthetic upon protagon, which according to him forms a considerable portion of the corpuscles (vide paragraph Blood). Protagon was discovered by Liebreich (*Annales de Chemie et Pharmacie*, No. 134) to exist in nervous tissue in considerable abundance, and Hermann supposes that anæsthesia may be produced by the action of the anæsthetic upon the protagon in the brain. Although the blood-corpuscles are dissolved by an excess of the anæsthetic, such is not the case when it is inhaled, the quantity necessary to produce anæsthesia being too small to dissolve the corpuscles. Of course no definite conclusion as to the mode in which the anæsthetic acts can as yet be arrived at from this interesting research.

Dogiel (*Reichert and Du Bois Reymond's Archives*, No. 2, 1866), from numerous experiments on rabbits and frogs, concludes that the contraction of the pupil in the first stage of chloroformisation is due to irritation of the cerebro-spinal centres, causing increased action of the circular fibres of the iris; and that the dilatation of the pupil when narcotism is complete, is not due to any irritation of the sympathetic, but to suspension of the function of the 3rd pair. His experiments also support the theory of the inhibitive function of the vagus; he found that during the stage of excitement of the cerebro-spinal centres the heart's action was less rapid, and sometimes even stopped for a second or two, while during narcotism the action was much more frequent, the decrease being due to irritation, and the increase to diminished function of the vagi. He divided the vagi, and then gave chloroform to complete anæsthesia, no change in the heart's speed was then observed.

Researches by Laschkewich on the CALABAR BEAN (*Virchow's Archives*, Feb. 1866) confirm but do not add any important facts to those discovered by Fraser and Robertson. Special notice ought however to be taken of the fact that he entirely confirms Dr Fraser's observation—that, when taken internally as well as when applied to the conjunctiva, the Calabar Bean produces contraction of the pupil.

Guttmann, of Berlin, from experiments on the poisonous properties of NITRO-BENZOLE (*Reichert and Du Bois Reymond's Archives*, No. 1, 1866) has been unable to confirm the observations of Letheby, that the symptoms of poisoning may appear from 19 to 72 hours after the poison has been taken; according to him they always appear shortly afterwards. It belongs to the group of narcotic poisons. Guttmann has also confirmed Kölliker's statement that CONIA has the same action upon the motor nerves as Woorara (*Berlin Klin. Wochenschr.* No. 5—8, 1866).

RESPIRATION.

In the *Centralblatt* for 3rd January, Czermak (now of Jena) gives an account of an experiment to show that the blood may be so sur-

charged with oxygen that a state of apnœa lasting even for a minute and a half may be induced. He took from three to six gentle inspirations in 15 seconds and then a final deep inspiration, and found that he could hold his breath for 30 seconds, but no longer. Again, he took from ten to eighteen inspirations in the 15 seconds and again ended them with a deep inspiration, he then found that a minute and a half elapsed before he felt the same desire to renew respiration that he had done in previous part of the experiment. He repeated the experiment an endless number of times with the same results. Rosenthal had previously shown this to be the case by experiments on animals; he opened both pleural cavities and kept up respiration by means of a pair of bellows, and found that after rapid inflation for some time the respiratory muscles remained at perfect rest for even a minute.

Dr Drosier in an interesting article on THE FUNCTIONS OF THE AIR-CELLS AND THE MECHANISM OF THE RESPIRATION IN BIRDS (*Proceedings of Cambridge Philosophical Society*) combats the ordinary views regarding the object of these cells, and puts forth the view that they form an auxiliary to the lungs; the abdominal and thoracic sets of air-cells alternately contract, and as both communicate with the lungs, they keep currents of air constantly playing through the latter.

CIRCULATION.

Landois, of Greifswald, from experiments made with Marey's SPHYGMOGRAPH used as a CARDIOGRAPH, calculates that the heart's diastole occupies three-fifths and systole two-fifths of each cardiac revolution. The systolic period in this calculation includes the auricular and ventricular contractions. According to his observations also, the time occupied by the auricular contraction is sometimes a little shorter, at other times a little longer, than that occupied by the ventricular contraction; a circumstance which may with every reason render his conclusions of questionable value. *Centralblatt*, 10th March, 1866.

According to Donders (*Nederl. Archiv voor Genees-en Naturk.* II. p. 139, vide *Centralblatt*, 5th May, 1866) the duration of the cardiac systole is of very constant duration, so that the chief difference between a quick and slow pulse depends on the duration of the heart's pause. The first sound begins with the cardiac systole and continues during the whole period of the ventricle's contraction, immediately upon the termination of which follows the second sound.

Onimus and Viry, of Paris, have a long paper in the January and March Numbers of the *Journal de l'Anatomie* on the tracings obtained with the Sphygmograph and Cardiograph; they recount numerous experiments serving to explain many of the phenomena of the circulation, and give a general sketch of the whole subject. The paper, however, is one which must be perused entire in order to be of much service.

NERVOUS SYSTEM.

Czermak (*Jenaische Zeitschr. für Med.* II. 384—386, vide *Centralblatt*, 20th Jan. 1866) has found that by pressure upon his right vagus at the border of the sterno-mastoid he can produce a decided diminution in the frequency of the pulse: at the same time the inspiration becomes deeper and longer. These phenomena are ascribed by him to irritation of the vagus. He has not succeeded in performing this experiment upon

others; in his own case he applies the pressure upon a little hard knot (possibly a lymphatic gland), which perhaps facilitates the effect of the pressure.

Beresin, of St Petersburg (*Centralblatt*, 24th Feb. 1866), from researches on the lumbar nerves of the frog, concludes that impressions which produce sensation are conveyed along nerve-tubes distinct from those which convey impressions to produce reflex action.

Setschenow (*Henle and Pfeuffer's Zeitschr.* (3) XXVI. p. 292, vide abstract in *Centralblatt*, 28th April, 1866) relates an experiment which shows the remarkable sensibility of the skin of the frog for acid irritants. He poisoned a frog with alcohol, and then found that although violent pinching of the skin supplied by the sciatic nerve produced no diastaltic movements, its irritation by means of dilute sulphuric acid energetically called them forth.

Paschutin (*Henle and Pfeuffer*, and *Centralblatt*, same numbers) continues his researches on the Inhibitory Influence of the Brain upon Reflex Action (vide *Centralblatt*, 1865, p. 792).

To his previous observations, that irritation of the brain *increases* "tactile" reflex action (that produced by titillation), while it diminishes the tendency to reflex action called forth by irritation of the skin with acids, he adds, that decapitation *lowers* the tendency to "tactile" reflex action. On division of the lateral half of the spinal cord the "tactile" reflex action on the same side, below the division, is lowered, while on the other side it is unaltered, or even increased; but when the brain is cut off immediately below the corpora quadrigemina the difference between the two sides ceases.

In the *Edin. Med. Journal* for March, 1866, Dr Sanders has published a case of APHASIA, to which he has added an excellent résumé of the whole question as to the seat of the cerebral faculty of speech. This case supports Broca's conclusion, that aphasia depends on lesion of the posterior part of the external or inferior left frontal convolution. In a second case, published by him in June, this portion of the brain however was affected to only a slight extent, the chief lesion occupying the anterior and external portion of the Island of Reil. Bearing on this question are important papers by Dr Moxon "On the Connection between loss of Speech and Paralysis of the right side." *Brit. and For. Med. Rev.* April, 1866, Dr Hughlings Jackson, "Notes on PHYSIOLOGY AND PATHOLOGY OF LANGUAGE," *Med. Times and Gaz.* 23rd June, 1866, and Prof. Gairdner, "ON THE FUNCTION OF ARTICULATE SPEECH AND ITS CONNECTION WITH THE MIND AND THE BODILY ORGANS," pp. 39, Glasgow, 1866, and "CASE OF APHASIA OR SPEECHLESSNESS OF CEREBRAL ORIGIN WITHOUT DISTINCT PARALYSIS, AND FATAL WITH EPILEPTIC CONVULSIONS," pp. 15, Glasgow, 1866.

MUSCULAR SYSTEM.

The DEVELOPMENT OF STRIPED MUSCULAR FIBRE in the Vertebrata is the subject of an excellent paper by Dr Braidwood (*Brit. and For. Med. Rev.* April, 1866). This paper is Dr Braidwood's thesis for which he obtained a gold medal at the graduation in Edinburgh in 1864. He has confirmed Savory and Lockhart Clarke's observation, that striped muscular fibre is developed from a molecular blastema; he has extended the research by observing the development of the fibrillæ and sarcolemma. The following are his conclusions: Muscle is developed from a molecular blastema of an oleo-albuminous character; nucleated nuclei or cytoblasts appear in it; the blastema next undergoes a process of fibrillation,

the cytoblasts arrange themselves linearly between the fibrillæ, and ultimately break up into "clusters of granules." A fibrilla at the earliest period of its existence consists of a chain of "globular particles" united by homogeneous blastema; these "globular particles" afterwards become square-shaped and form the "light spaces." The sarcolemma is formed from the molecular blastema; the cytoblasts contained in it however do not break up into granules, but continue as the nuclei of the sarcolemma.

We have already two MYOGRAPHIONS, Pflüger's and Du Bois Reymond's; to these Marey has added a third, by means of which muscular contraction may be studied *in situ;* with both Pflüger and Du Bois' instruments muscles must be cut out and fixed to them, with Marey's myograph this is unnecessary. Marey terms the instrument "myographic forceps," from the fact that a portion of the body is seized by a pair of forceps, the limbs of which are connected to one another by a joint at their middle; while the one extremity of the forceps grasps the group of muscles, the other is connected with a moveable lever—similar to that employed in Marey's sphygmograph—by means of a tube filled with water on the principle adopted in the construction of the cardiograph. The arrangements are such that the slightest vibration of the limbs of the forceps is communicated to the lever, the moveable extremity of which is brought in contact with a revolving cylinder, and produces a tracing upon it. Marey has investigated the nature of tetanic contraction by grasping the muscles situated between the thumb and forefinger with the myographic forceps, and throwing the muscles into action by means of an interrupted galvanic current: the physiological facts he has ascertained thereby are not, however, new. The advantage offered by the instrument is, that by means of it variations in muscular contraction may be subjected to clinical investigation. (*Journal de l'Anatomie,* May, 1866.)

PHYSIOLOGICAL AND PATHOLOGICAL CHEMISTRY.

Muscle.—Professors Fick, and Wislicenus of Zurich (*Lond., Edin. and Dub. Phil. Mag.* June, 1866) give an account of an experiment which seems conclusively to show the error of Liebig's theory that muscular power is derived from the oxidation of muscle, and the truth of that advanced by Bischoff and Voit, that the oxidation of hydrocarbonaceous material is the source of that power. They ascended the Faulhorn, a peak of the Swiss Alps; during the ascent, for eighteen hours previous and six hours after it, they took hydrocarbonaceous food only: and it was found that the great muscular exertion had but very slightly increased the amount of urea excreted, and that during the six hours after the ascent even less urea was excreted than before starting. Had the source of muscular power been the oxidation of albuminous material, the urea excreted during, and shortly after the ascent, ought to have undergone a very decided increase. They compare a muscle to a steam-engine; the iron framework is represented by albuminous material, which is worn to some extent by the muscle's action, just as the iron is by the working of the engine; in the muscle, as in the engine, hydrocarbonaceous material is burned to produce force.

With the above conclusions Professor Frankland agrees (*Lond., Edin. and Dub. Mag.* September, 1866). After giving several very valuable tables of results of experiments as to the actual energy generated by the oxidation of given weights of muscle, albumen, fat, &c., he sums up a long and interesting article with the following conclusions. "1. A muscle is a machine for the conversion of potential energy into mechanical force. 2. The mechanical force of the muscles is derived chiefly, if not entirely,

from the oxidation of matters contained in the blood, and not from the oxidation of the muscles themselves. 3. In man, the chief materials used for the production of muscular power are non-nitrogenous; but nitrogenous matters can also be employed for the same purpose, and hence the greatly increased evolution of nitrogen under the influence of a flesh diet, even with no increase of muscular exertion. 4. Like every other part of the body, the muscles are constantly being renewed; but this renewal is scarcely perceptibly more rapid during great muscular activity than during comparative quiescence. 5. After the supply of sufficient albuminoid matters in the food of man to provide for the necessary renewal of the tissues, the best materials for the production both of internal and external work are non-nitrogenous matters such as oil, fat, sugar, starch, gum, &c. 6. The non-nitrogenous matters of food which find their way into the blood, yield up all their potential energy as actual energy; the nitrogenous matters on the other hand, leave the body with a portion (at least one-seventh) of their potential energy unexpended. 7. The transformation of potential energy into muscular power is necessarily accompanied by the production of heat within the body, even when the muscular power is exerted externally. This is doubtless the chief, and probably the only source of animal heat."

Matteuci, in a letter to Professor Frankland (*Ibid.* October, 1866), while admitting the accuracy of the above conclusions, says that from his experiments upon frogs' muscles he "cannot avoid conceding that the muscular fibre itself is also oxidized and burnt during contraction."

Nawrocki of Breslau (*Centralblatt*, June 2, 1866) has from experiments upon frogs' muscles come to a similar conclusion; he finds that the albuminous constituents of muscle are wasted during its contraction, a conclusion which had indeed been previously arrived at by Ranke of Munich in his excellent researches upon Tetanus.

Fick, Wislicenus and Frankland do not however deny that the albuminous constituents of muscle are wasted to some extent during its contraction, but the legitimate conclusion deducible from their researches, seems undoubtedly to be, that in normal conditions during contraction the oxidation of albuminous matter, bears a very small proportion to that of hydro-carbonaceous material.

Virchow (*Virchow's Archives*, Feb. 1866) has made an interesting observation as to concretions in muscle of a pig, which were thought to be calcareous, and due to Trichinae. He found that they consisted of organic matter, which he thought was most probably Guanine, a substance closely allied to Uric Acid and Hypoxanthine (Sarcine). He concludes that pigs are subject to a disease which is accompanied by the formation of Guanine deposits, just as Gout is attended by the deposition of those of Urate of Soda; and supposes it to be a sort of Guanine-gout. It shows that a very careful examination must be made of meat supposed to be Trichinous, before it be definitely pronounced to be so.

Milk.—Urea has hitherto been regarded as an abnormal constituent of milk, but Lefort has obtained 1·30 gramme of Nitrate of Urea from 10 litres of ordinary cow's milk (*Journal de Pharmacie et de Chemie*, March, 1866). From researches on the influence of diet on the composition of milk (*Centralblatt*, 12 May, 1866), Ssubotin, of St Petersburgh, concludes, that in dogs a flesh diet increases relatively as well as absolutely the amount of fat in the milk, and to a less extent the casein also: a vegetable diet diminished the absolute quantity of the milk as well as the proportion of butter and casein: especially interesting is the fact, that a fatty diet caused such a diminution in the secretion that in some instances it totally disap-

peared, and only returned when another diet was adopted. He concludes, from the butter's being increased by a flesh diet and diminished by a fatty diet, that fat is formed from albuminous principles in the mammary gland.

Blood.—Hoppe-Seyler, of Tubingen (*Medicinisch-chemische Untersuchungen*, 8vo, pp. 168, Berlin, 1866), has investigated more exactly the effects of Sulphuretted Hydrogen upon the blood and solutions of its Hæmoglobin combined with oxygen. The first effect consists in a diminution of the combined oxygen; in ammoniacal solutions, of Hæmoglobin no further decomposition generally occurs; in neutral solutions, however, further action of the HS brings out an absorption band in the red portion of the spectrum, exactly midway between the lines C and D. According to Kaufmann and Rosenthal this is the Hæmatin band; but according to Hoppe-Seyler it belongs to no previously known colouring matter, for the band produced by acid Hæmatin, solutions of Hæmatin and Methæmoglobin, occupies a different position in the spectrum. He regards it as a compound of Hæmatin or Hæmoglobin with sulphur, but has not been able to isolate it: it is produced, although an excess of oxygen be passed through the solution of Hæmoglobin at the same time as the HS. By still further action of HS a substance is produced which is olive-green in thin, and brownish red in thick strata, and does not produce an absorption band; at the same time sulphur and an albuminous substance is precipitated. Decomposition of the HS only occurs in the presence of oxygen, and is due to the formation of ozone. This is confirmed by Lewisson (*Virchow's Archives*, May, 1866), who also corroborates Hoppe-Seyler's statement, that AsH_3 and SbH_3 produce the same changes upon the blood as HS, and, like it, are in their turn decomposed, the peculiar absorption band observed after treating the blood with HS was also observed after its treatment with AsH_3 and SbH_3. In opposition to Kaufmann and Rosenthal's opinion that in poisoning with HS death is due to suffocation, Hoppe-Seyler avers that in true suffocation the blood is found to be almost destitute of oxygen, whereas in animals killed by HS the blood is rich in oxygen, and that animals die notwithstanding the simultaneous introduction with the HS of oxygen, sufficient not only to oxidize the HS, but to preserve life. He supposes that death is due to paralysis of the respiratory substance, owing to a compound being formed between it and the HS, or owing to its decomposition by the HS. Dybkowsky (Hoppe-Seyler's *Medico-Chemische Untersuchungen*, 1866) has ascertained that the greater part of the oxygen contained in the blood is loosely combined with the Hæmoglobin. Rollett (*Sitzungsbericht der Wiener Akad.* Vol. LII. p. 246) finds that if freshly whipped arterial blood be shaken with clean iron filings it becomes darker in hue from two causes; 1st, from purely mechanical destruction of the blood corpuscles; 2nd, from the iron's abstracting oxygen from the oxygenated Hæmoglobin. When iron filings are brought in contact with the blood, and the air excluded, the Hæmoglobin is so altered that both the absorption bands of oxygenated Hæmoglobin disappear, and instead of them a broad band appears between D and E in the spectrum; when air is admitted to the blood so altered, the two bands produced by oxygenated Hæmoglobin again appear. The oxygenated Hæmoglobin may also be reduced by shaking with finely divided tin, lead, antimony, and a neutral substance, such as asbestos. Silver reduces it slowly, platinum and quicksilver not at all. Preyer (*Centralblatt*, 5 May, 1866), in an account of researches on the relations of oxygen and carbonic acid in the blood, says "that the circumstance of Pflüger, Schöffer, and his having found only a minimum quantity of oxygen in the serum of dog's blood, taken in connection with the fact which he has ascertained, viz. that a moderately thick stra-

tum of the purest serum gives the Hæmoglobin absorption bands, discovered by Hoppe-Seyler, render it in the highest degree probable that all the oxygen of the blood which can be disengaged by a vacuum is attached to the colouring matter, by far the greater portion being therefore contained in the blood corpuscles, while a minute quantity belongs to the Hæmoglobin diffused through the serum." As regards the carbonic acid, his researches give great probability to Fernet's view, that the carbonic acid derived from the tissues forms a compound with phosphate of soda, which is readily decomposed in the lungs, and so gives up its carbonic acid to be expired. He has succeeded in forming this compound, the formula of which he has not as yet however determined. The Protagon discovered by Hermann in the blood (*Reichert and Du Bois Reymond's Arch.* No. 1, 1866) exists in the blood corpuscles, and is, according to his opinion, probably the phosphorized fat long recognised to be one of their constituents.

Urine.—Schunck (*Proc. Roy. Soc.*, Jan. and June 1866) considers that normal human urine contains at least two distinct colouring matters, one of which is soluble in alcohol and ether, and has the formula $C_{86}H_{51}NO_{52}$, while the other is soluble in alcohol, but insoluble in ether, and has the formula $C_{38}H_{27}NO_{28}$.

Cunisset (*Journal de Chemie Medicale,* Jan. 1866) proposes the following test for the presence of bile in urine. Add to urine in a test tube $\frac{1}{10}$th of its bulk of chloroform, and shake; if the mixture become yellow, bile is present, and if it be allowed to stand, the chloroform sinks to the bottom, taking the colouring matter of the bile with it. This test has evidently been suggested by Brücke's method of separating the brown colouring matter of the bile; he pointed out, a good while ago, that if bile be shaken with chloroform it becomes yellow, and on standing the chloroform sinks to the bottom, drawing the Biliphaeine with it.

Dr Keith Anderson (*Ed. Med. Jl.* Feb. 1866) has found, from researches on the daily excretion of Urea in typhus fever, that "in all cases the quantity of Urea excreted daily, during the second week, was decidedly below the standard of health, notwithstanding that the patients were in a state of high fever, with the temperature and pulse much above the normal rate." The results are very different from those obtained by Parkes.

Quinoidine.—One of the most interesting discoveries in recent Animal Chemistry is that by Messrs Bence Jones and Dupré (*Proc. Roy. Soc.* p. 73, 1866) of a fluorescent substance diffused throughout all the tissues of man and of some of the lower animals. This substance, in addition to its being fluorescent like quinine, has, when isolated, "a very close optical and chemical resemblance to that substance, and when it is mixed with it, it cannot be separated from it: its discoverers therefore term it Animal Quinoidine." It is "identical with the fluorescent substance which for some years has been known to exist in the lenses of man and animals." As has been pointed out, the discovery of this substance must give rise to new speculations regarding the nature of intermittent fever and the action of quinine as its remedy. The discovery was made during the progress of researches to ascertain the rapidity with which quinine becomes diffused throughout the tissues; they found that in guinea-pigs quinine passes into all the vascular, and most probably all the extra vascular textures in fifteen minutes: it takes three hours for the amount in the textures to reach its maximum; for six hours it does not diminish; in twenty-four it sinks considerably, and in forty-eight hours it is scarcely perceptible anywhere.

Xanthin.—Almén (*Centralblatt,* Jan. 20th, 1866) finds that ox's liver contains 0·02—0·024 per cent. of Xanthin.

Leucin and Tyrosin.—Radziejewsky, of Posen (*Virchow's Archives*, May, 1866), in an excellent paper on the occurrence of leucin and tyrosin in normal bodies, states that after many researches he comes to the conclusion that tyrosin never occurs in any organ in a normal condition. Leucin is present in very variable quantity in the liver, pancreas, spleen, lymphatic, salivary, thyroid and thymus glands; it is absent from the lungs, brain, heart, and other muscles, blood, urine, bile and saliva; its presence in the kidneys and testes is doubtful.

Glycogen.—Foster (*Proc. Roy. Soc.* Lond. Jan. 1866) has found a very considerable quantity of glycogen in the tape-worm and round worm (Ascaris Lumbricoides) of the pig. A trace of sugar was found, but he could discover no sugar-forming ferment. Here we have an animal living on a fluid containing sugar-forming ferment in abundance, and yet accumulating glycogen. According to Dr Foster's supposition it either refuses the ferment or destroys it immediately on its being swallowed.

Bizio, of Venice (*Comptes Rendus*, No. 12, 1866), has found a large quantity of glycogen in the tissues of acephalous molluscs, e.g. oyster, pecten, &c.

The occurrence of glycogen in the organs of diabetic patients, which was ascertained by Grobe in 1864, was considered to be independent of the diabetes by Kühne in 1865. Jaffe, of Königsberg, has investigated the subject (*Virchow's Archives*, May, 1866); he has found that glycogen seldom occurs in the organs of diabetic patients; it was found in only three instances, once in the brain, once in the spleen, and once in the pia mater, in a case where there was suppurative meningitis. These are the results from an examination of the organs of four cases of diabetes. He examined three normal brains, and found a large quantity of sugar-forming substance.

"Physiological Relations of Colloid substances." Mr Arthur Ransome, of Manchester (*Brit. Med. Jl.* Feb. 3, 1866), gives a *résumé* of the admirable discoveries of Graham, regarding the class of colloid substances. He makes some important suggestions regarding the assistance which they afford to explain the phenomena of digestion. He raises objections to the theory that Pepsine and Ptyaline act as ordinary ferments during digestion, and advances the following in its stead. "The changes produced during digestion are chiefly brought about by purely molecular influences analogous to the so-called catalyses wrought by many inorganic substances." He thinks that Ptyaline and Pepsine are colloid substances which play the part of catalytes, by whose action fibrine, coagulated albumen &c., are liquefied, rendered easily diffusable, and in consequence easily absorbed.

Animal Heat.

Pouchet (*Journal de l'Anatomie*, Jan. 1866) recounts many interesting observations on the congelation of animals, from which he concludes that complete congelation of an animal is incompatible with life. This conclusion is supported by Dr Davy (*Proc. Roy. Soc.* Lond. p. 250, 1866), by whom some of the experiments have been repeated. Pouchet supposes that death from local or general freezing is due to an alteration of the blood; by freezing, the blood-corpuscles are disintegrated; and according to his theory the mischief done to the system at large is directly proportionate to the amount of blood so altered, and to the rapidity with which it reenters the general circulation, in other words, to the extent of the frozen part and the rapidity with which it is thawed. With this alteration of the blood by freezing we have, by the bye, been acquainted since the observations of Böttcher on that subject. That we may completely freeze a part without

destroying its vitality is proved every day by producing local anæsthesia, after Richardson's method; we still want to know, however, the length of time during which we may with safety keep up the frozen state. Any one generally acquainted with the multitude of facts which have been observed relative to the effects of low temperatures upon the body, will at once perceive that the explanation of Pouchet will not suffice to account for many of them. He seems to have overlooked the exhausting influence of cold upon the nervous system, and its depressing effect upon the vitality of the tissues in general.

Walther, of Kiew (*Centralblatt*, April, 1866), has, from experiments upon rabbits, arrived at a theory as to the cause of death in animals exposed to cold, which is much more probable than Pouchet's. He found that when white rabbits were exposed to a temperature of from 31·7 to 42·4° Fahr. the fundus oculi becomes pale from emptying of the capillaries of the retina and choroid, and that this appearance coincides with extinction of the functions of the cerebro-spinal system; moreover, he says that the symptoms of this mode of death are identical with those due to death from anæmia of the central organs; he therefore supposes death from exposure to cold is due to anæmia of the nervous system and other organs. He has also found that we can revive a frozen animal, which has been apparently dead for forty minutes, by employing artificial respiration together with artificial warmth: and he further found, that all animals which have been frozen and resuscitated suffer during the following days a more or less marked loss of weight. Should these experiments of Walther's be confirmed, they will place the question of congelation of animals in a less hopeless light than Pouchet's have attempted to do; if an animal which has been frozen and rendered apparently lifeless for forty minutes can be revived, the question as to the fatal change in the blood, upon which Pouchet lays such stress, need not much trouble us.

The effect of the nervous system upon animal heat has been made the subject of research by Tscheschichin (*Reichert and Du Bois Reymond's Arch.* No. 2, 1866). The following are some of his conclusions: 1. The spinal cord, being the centre of circulation and respiration, has an indirect action upon the chemistry of the organism, and consequently upon the animal heat. 2. Section of the spinal cord produces retardation of the circulation and distension of the vessels with blood, in consequence of which the radiation of heat is increased and the general temperature rapidly lowered. 3. Section of the sympathetic and all agents which produce paralysis of the vessels have an effect upon the radiation of heat similar to section of the spinal cord. 4. Section of the medulla oblongata, where it joins the pons, produces violent febrile symptoms. 5. Physiological experiments, together with clinical observations, prove the presence in the brain of centres which regulate the temperature of the body.

Animal Ingrafting.

Who would have supposed that a rat's tail after removal of the skin might be kept in a glass tube for 62 hours at 15—17° Fahr.; or kept for a still longer period in moist air at 121° Fahr.; or after being subjected to a temperature 31° below the freezing point; or, finally, after being dried in an air-pump over sulphuric acid, and enclosed in a glass tube for three days, then exposed to a temperature of 175° Fahr. in a hot air-chamber, and again enclosed in a glass tube for four days—who would have supposed that the unfortunate tail might be subjected to such a treatment and yet live on its being placed below the skin of the back of a rat? These remarkable

facts regarding the vitality of the tissues have been ascertained by Dr Bert, assistant to Claude Bernard, *Comptes Rendus*, LXII. p. 89, and *Annales des Sciences Naturelles*, 1866. Through Dr Bert's kindness I had an opportunity of witnessing the results of two such experiments; in one, the revived tail had been frozen, in the other it had been kept for three days in moist air at 121° Fahr.; on the animal's being injected it was found that there was free vascular communication between the ingrafted tail and the surrounding tissues. He, moreover, finds that the tissues which have been subjected to such modifying influences are liable to fall into certain diseased conditions, the progress of which may be traced by killing the animal at different stages. In the prosecution of this research he is still engaged.

He has also succeeded in joining together animals not only of the same but of different species, not only rats to rats, but actually a rat to a cat! He effected this by denuding corresponding parts of their sides, and then uniting by means of sutures the skin of the one animal to that of the other, and tying the two animals together so as to prevent their tearing themselves apart. The practical importance of such researches does not require to be dwelt upon.

Animal Electricity.

Dr Radcliffe (*Proc. Roy. Soc. Lond.* May, 1866) gives "An Account of experiments in some of which electroscopic indications of animal electricity were detected for the first time by a new method of experimenting." He has arrived at the conclusion that the primary condition of animal electricity is not *current*, as has been generally supposed, but *statical.* According to him, "all parts of the surface of muscle or nerve are electrified with the same kind of electricity, positive or negative, as the case may be, the only difference between one part and another being one of degree," and the currents which are rendered evident by the galvanometer are "secondary phenomena, developed accidentally by placing the ends of the coil of the galvanometer so as to include points in which the electricity is different in degree." In order fully to understand Dr Radcliffe's proposition, it is necessary to remember that by means of the galvanometer a current may be shown to pass from the longitudinal to the transverse surface of a muscle or nerve; it was in consequence said by Du Bois Reymond, the discoverer of this fact, that the longitudinal surface is charged with +, and the transverse with – electricity. But Du Bois also ascertained that a current may be shown to exist between any two points of the longitudinal or transverse surface, which are not equidistant from their respective centres, and he was compelled to admit that this can only be explained by supposing that all the points on the two surfaces are not charged with electricity to the same degree, and that in consequence, a current may be obtained by bringing any two such points unequally charged with the same electricity in contact with the electrodes of the galvanometer. But if a current may be obtained from parts of the same surface on account of the disparity in the proportion of electricity which they contain, why might we not explain the current passing from the longitudinal to the transverse surface of muscle and nerve in the same manner, viz. by supposing that the longitudinal has simply more electricity than the transverse? This is the view suggested by Dr Radcliffe and supported by his experiments, and it has the advantage of doing away with an anomaly in Du Bois Reymond's explanation of these electrical phenomena, which has proved a stumblingblock to many. Dr Radcliffe further suggests, however, "that these currents may in reality

be due to a retarded discharge of statical electricity; for it is a fact that they cannot be detected without a coil of which the wire is so long and so fine as to be capable of giving sufficient resistance to bridle a discharge into the quieter pace of ordinary currents." His experiments also include some which seem to render certain the presence of electricity in living blood.

According to Robin (*Journal de l'Anatomie*, 1866, No. 1) the current in the electrical ray is directed from the head to the tail. This direction is the same as that taken by the current in the melapterurus, but instead of its being also the same as in the gymnotus, as Robin says, it is just the opposite.

Speech.

In the *Lancet*, 27th Jan. 1866, Mr Syme gives a second notice of a case in which he had excised the tongue a year before; no vestige of the tongue remained, yet the patient possessed the power of speech and deglutition so perfect that he "dined at table d'hôtes, and entered into conversation without betraying the deficiency under which he laboured." All the vowels were articulated perfectly, as well as all the consonants excepting d, which was pronounced dthe, j as the, g as sjee, s was a mere lisp. His taste was impaired; he could distinguish different articles and perceive their qualities, only, however, on their being swallowed, for there was no recognition of the substance previous to the act of swallowing. The patient referred the seat of taste to somewhere in his throat; this was corroborated by brushing saline and saccharine solutions over the whole of the inside of the mouth and palate without, however, his perceiving the nature of the substance until he swallowed it.

Voice.

Panofka (*Comptes Rendus*, No. 8, 1866) asserts that the 17—20 rings composing the trachea correspond to a like number of semitones which compose the ordinary range of the voice: he supposes that each ring may be approximated separately, and thereby produce a note whose pitch bears relation to the length of the column of air thrown into vibration above the constriction. What about the bronchial rings?

Vision.

Max Schultze, in a pamphlet upon the macula lutea and its influence upon normal vision and colour-blindness, agrees with Helmholtz in referring the dark spot observed in the centre of the visual field, when illuminated with blue light, to absorption of the blue rays by the yellow spot. He further advances the opinion that, owing to the absorption of the blue rays by the macula, the visible spectrum is somewhat shortened at its violet extremity: if the colouring of the macula be very intense, the violet rays are absorbed to such an extent that the person may be blind as regards them, but if the pigmentation be but slight, violet will be clearly distinguished. Perhaps also by the absorption of the strong chemical rays a prejudicial effect upon the light-perceiving elements of the retina is prevented (Max Schultze, "Ueber der gelben Fleck der Retina, seinen Einfluss auf normales Sehen und auf Farben Blindheit." Bonn, 8vo. pp. 16, 1866. Abstracted in *Centralblatt*, 2nd June.

Donders (*Nederl. Archiv. voor Genees-en Naturk.* II. p. 109) gives an experiment by which he has proved that the movements of the pupil are

not simultaneous with the movements of the mechanism for accommodation. If a drop of quicksilver be placed upon a flat piece of glass and held close under the eye, so that a clear circle corresponding to the pupil is perceived, while through the glass a white spot on a dark ground is visible: if the eye be accommodated for distance, the spot becomes indistinct before the pupil dilates, and if accommodated for near objects, the spot becomes perfectly distinct before the pupil contracts.

He also relates an experiment to show that both pupils move simultaneously, although the light producing the movement only affects one (Ibid. p. 106).

Non-regeneration of the Spleen.

Pergrani (*Comptes Rendus*, LXII. p. 89), in opposition to the recent communication of Philipeaux, maintains his opinion that the spleen, when extirpated in whole or in part, is never regenerated.

Salivary Secretion.

Eckhard (of Giessen), in a note concerning the salivary secretion, says that in the horse the saliva obtained from the parotid gland during irritation of the sympathetic differs both from the submaxillary secretion under the same circumstances, and from the parotid secretion due to irritation of the branches of the fifth nerve. It is less tenacious than the submaxillary, and under the microscope may be seen to contain numerous fine, strongly refracting particles, but none of the protoplasmic masses which Eckhard was the first to observe in the submaxillary sympathetic secretion. It is distinguished from the parotid secretion due to irritation of the fifth nerve by its density and turbidity.

The Bursa Fabricii.

Dr Davy having examined this organ, respecting which such various views are entertained, in above thirty different species of birds, and at different ages, comes to the conclusion that in some birds, probably in all the gallinaceous, it increases in size and completeness up to a certain age, and then gradually diminishes in both sexes, and eventually disappears. That in other birds, those of rapid flight, it is comparatively large whilst they are nestlings, does not increase with their growth but rather diminishes, and after a certain age disappears.

Of the uses of the organ he ventures to conjecture, founding his conjectures on what he has observed, that they may be provisional and various; that in some birds, whilst nestlings, it may act the part of a urinary bladder, as witnessed in the instance of the young owl, and in some of the young rooks, crows, and thrushes, thereby tending to prevent the fouling of the nests; that in others it may serve as a seminal reservoir at an early period, and in both male and female in the instances mentioned, in which it has been found most completely formed before the attainment of full size —in the male before the vasa deferentia are fully developed, in the female so long as the oviduct is still small and unexpanded; and that generally, as the organ is more or less amply supplied with mucous follicles, it may serve, by the secretion it yields, to lubricate the cloaca with which it is connected, and to aid in its functions. *Proc. of Royal Society*, xv. 94.

Laws of Human Fertility and Sterility.

Dr Matthews Duncan, in a valuable paper read before the Royal Society of Edinburgh (*Trans.* Vol. xxiii.), showed that the total fertility of fertile women diminishes as the age at which marriage takes place increases. Although the fecundity of women who marry at 25 is greater at the time of marriage than is that of those who marry at 15 or 20, yet the latter become much more generally persistently fertile, and therefore productive of larger families than when marriage takes place at a more advanced age. He finds that there is absolute sterility in about 7 per cent. of those marrying between 15 and 19; whereas of those marrying between 20 and 24 almost none are sterile. Dr Duncan's conclusions are based upon statistics of more than 16,000 families.

New Physiological Works.

O. Nasse. *Beiträge zur Physiologie der Darmbewegung.* 8vo. pp. 70. Leipsic, 1866.

Kühne. *Physiologische Chemie.* Part I. Digestion, 8vo. Leipsic, 1866.

Duchenne. *Physiologie des Movements.* Part I. 8vo. Paris, 1866.

Duméril and Jacquart. *Mémoire sur la Deglutition chez les Ophidiens.* 8vo. Paris, 1866.

Fournie. *Physiologie de la Voix et de la Parole.* 8vo. Paris, 1866.

Vulpian. *Leçons sur la Physiologie Générale et Comparée du Système Nerveux.* Vol. I. Paris, 1866.

Austin Flint. *The Physiology of Man.* Part I. 8vo. New York, 1866.

Beale. New edition of *Todd and Bowman's Physiology.* Part I. London, 1866.

ON THE WORK PERFORMED IN PILE-DRIVING; by Dr F. C. DONDERS, *Professor of Physiology and Ophthalmology in the University of Utrecht.* Translated from the *Nederlandsch Arch. v. Genees- en Naturkunde* II. p. 210, by W. D. MOORE, M.D. Dub. et Cantab., M.R.I.A.

I LATTERLY had occasion repeatedly to witness a work, which the loose texture of our soil not unfrequently renders necessary: I mean pile-driving. It is well known that in this process a heavy block is lifted up, almost without friction, in a fixed measure to a certain height and thence let loose, so that it descends with a blow upon the vertical pile which is to be driven into the ground. The work is still performed mostly by hand. A strong rope, attached to the upper extremity of the block, runs over a large, easily movable pulley, and passes at the other side into a certain number of slighter ropes, by which a like number of workmen raise the block.

It struck me, that in this process the work performed may be easily and certainly calculated. We need only to know the weight of the block in kilogrammes, the height to which it is each time raised in metres, and the number of blows, in order to find in the product of these three values the work performed in kilogrammeters.

Now on the site where the proposed physiological laboratory is to be constructed, piles are driven with a block of 160 kilogrammes, with which, on an average, 3365 blows are daily given, with an elevation of about 1·25 metres. We thus obtain a work of $160 \times 3365 \times 1{\cdot}25 = 673000$ kilogrammeters, performed by twelve persons: that is, 56083 kilogrammeters per man; the maximum I obtained was 60500.

The work does not go on continuously. Each time 30 blows are given at the rate of one blow in from 5 to 7 seconds. If we take 5 seconds, then in 150 seconds 6000 kilogrammeters are performed, or 500 per man, that is exactly 200 per minute, and 12000 per hour; and it hence appears, that ($56083 : 12000 =$) $4\frac{2}{3}$ hours are daily worked. In summer, however, the duration of work and that of interval are in the same ratio, and the working hours increase from 9 to 14: consequently a man in pile-driving in summer daily performs a work of $56083 \times 14 : 9 = 87241$, or, as a maximum, $60500 \times 14 : 9 = 94111$ kilogrammeters. With further movements, which he has to make, his work may increase to 100000 kilogrammeters: that is, he does the work necessary to bring 1 kilogramme to a height of 100000 metres, or 100000 kilogrammes to a height of 1 metre.

The work which the heart alone, in its constant activity during 24 hours, performs, occupies the mean between that of pile-driving in winter and in summer; I calculated, namely, for the heart 86400 kilogrammeters[1].

Picked men can do much more work. Thus Coulomb found in ascending the Peak of Teneriffe 204610 kilogrammeters per day of 8 hours, that is 25576 per hour, being double what would be performed in continual pile-driving. For ordinary workers, however, not much more is admitted, and the number found coincides very well with that of 86000 kilogrammeters per diem formerly assumed by me[2].

In pulling at the rope by which the block is raised, the extended arms and the vertebral column bend, and the knees advance from flexure of the hip and knee-joints, while the feet retain their position. The limbs and the trunk must now be again extended, in order anew to grasp the rope at

[1] *Physiologie des Menschen.* 2de Auflage, 1859, p. 110.

[2] Conf. *Nederlandsch Archief voor Genees- en Natuurkunde.* Deel 1, p. 240. See also *Dublin Quarterly Journal,* May, 1866, p. 471.

a higher point; but the effect of this extension once more turns to account, as gravitating force, in raising the block. Thus in this case almost all the muscular action seems to be useful. Meanwhile, as in general, so in this instance also, a good deal of the elastic energy of the muscles remains unused. A moment before the block was let loose, all the muscles were still in a state of high tension and as such were extended, and this tension is suddenly at once sacrificed. Were the block, just before, reduced at once to the half of its weight, it would, through this tension, fly further upwards, and the men pulling it would be thrown violently to the ground. Now the energy, which might be able to prevent both effects, the elastic tension, namely, of the muscles, gives way suddenly under the influence of the will, and we can scarcely imagine, that thence a new useful form of energy should arise: it is certainly most probable, that only heat should be developed from it. We shall endeavour to determine this experimentally.

The results here obtained moreover teach nothing more respecting the origin of muscular work from given matters than what I have already stated.

ON THE INFLUENCE OF ACCOMMODATION ON THE IDEA OF DISTANCE, by Dr F. C. DONDERS, *Professor of Physiology and Ophthalmology in the University of Utrecht.* Translated from the same Journal, p. 212, by W. D. MOORE, M.D. Dub. et Cantab., M.R.I.A.

THE importance of the consciousness of accommodation in the estimation of distance is by many considered to be very slight, by Wheatstone, I think, it was even wholly denied. Under peculiar circumstances, however, I some time ago very distinctly observed it. At Leipsic I occupied a room, the hangings of which exhibited a network of broad bright yellow stripes upon a finely black-streaked blue ground. When I now looked at a distance of from 10 to 12 feet towards the wall, the network of yellow stripes at once stood out in front of the blue wall, and assumed the appearance of a grating removed more than 20 centimetres (nearly 8 inches) from it. The illusion was so complete, that I involuntarily went towards the wall, whereupon the grating approached nearer and nearer to the blue ground, and at length all but coincided with it. A second proof of the completeness of the illusion lies in this, that on moving the head, hither and thither, the grating seemed to move before the wall,—evidently, because it really remained fixed in relation to the wall, in other words, because the parallactic movement was wanting, which a real grating before the wall would have exhibited on movement of the head. But, with Professor Ludwig, who also saw the network as a grating, the illusion disappeared on moving the head, precisely on account of the absence of the required apparent movement. On Dr Zöllner the illusion did not act strongly.

The phenomenon is explained by the stronger accommodation necessary to see the yellow network acutely, than to distinguish the black stripes upon the blue ground. The difference has, of course, its foundation in defect of achromasia of the eye, whereby blue rays are brought to a focus sooner than yellow ones. A red network on a purple ground would make the illusion still greater. In order to observe accurately the required difference in accommodation, it is desirable that the investigator should be emmetropic; or at least that he should be in a condition to judge correctly, at a certain distance, as to the acuteness of his accom-

modation. The fact that the illusion was less marked in the two friends I have named, may be ascribed to the absence of emmetropia.

I attach some importance to this observation, because it takes place with both eyes, and the difference in distance being only apparent, change of convergence is altogether out of the question. In other cases, even in observing with one eye, the accompanying change in convergence, which is such an important element in the estimation of distance, may determine the judgment, and therefore the influence of the consciousness of accommodation is not absolutely proved. From the above it follows, that a hanging with purple stripes on a dark ground must make the room appear larger than a similar one with yellow stripes.

As to the apparent movement, which with an incorrect idea of the distance, proceeds from movement of the head, I may refer to other circumstances, which have the same effect. We know that it is not difficult, by convergence of the visual lines, to displace the figures of a regular pattern, for example of a room-paper, so that we may see with both eyes a similar, but not the same figure (Brewster). The wall then appears soon to approach us, in order to place itself in the point of convergence of the visual lines. Under these circumstances a positive parallax now occurs, as soon as we move the head to the left or to the right, upwards or downwards; if we approach the wall, it appears to recede from us,—if we withdraw from it, it seems to follow us.

ANALYTICAL, CRITICAL, AND OTHER NOTICES, LETTERS, &c.

NOTICES OF RECENT DUTCH AND SCANDINAVIAN CONTRIBUTIONS TO ANATOMICAL AND PHYSIOLOGICAL SCIENCE. BY WILLIAM DANIEL MOORE, M.D., DUB. ET CANTAB.; M.R.I.A. &c. &c.

I. *Nederlandsch Archief voor Genees- en Natuurkunde onder medewerking van* P. Q. BRONDGEEST, M. IMANS, A. P. VAN MANSVELT *en* H. SNELLEN *uitgegeven door* F. C. DONDERS *en* W. KOSTER. *Utrecht.* 1865, 1866.

Dutch Archives of Medicine and Natural Philosophy, edited by F. C. DONDERS and W. KOSTER, with the cooperation of P. Q. BRONDGEEST, M. IMANS, A. P. VAN MANSVELT and H. SNELLEN.

1. *Over de Tong-werktuigen van het Stem- en Spraakorgaan, door* F. C. DONDERS. 1e Deel, 4e Aflevering, 1865, bl. 451.

On the Lingual Apparatuses of the Organ of Voice and Speech, by Professor DONDERS. Vol. I. Part 4, p. 451.

2. *Over den Invloed van Chloroform op Hartswerking, Ademhaling en Bloedsdrukking, in Verband met Doorsnijding van N. Vagus en van Curare-vergiftiging, door* P. Q. BRONDGEEST.

On the Influence of Chloroform on the Action of the Heart, Respiration and Pressure of the Blood, in connexion with division of the Nervus Vagus, and of poisoning with Curare, by P. Q. BRONDGEEST. *Ibid. p.* 473.

3. *Irradiatie op symmetrische deelen aan de tegenovergestelde zijde, door* F. Z. ERMERINS, *Hoogleeraar te Groningen.*

On Irradiation on Symmetrical Parts of the opposite side, by F. Z. ERMERINS, Professor at Groningen. *Ibid. p.* 498.

4. *De condylus tertius van het achterhoofdsbeen, door* H. J. HALBERTSMA.

On the Third Condyle of the Occipital Bone, by H. J. HALBERTSMA. *Ibid.* 524.

5. *De indrukking der grondvlakte van den schedel, hare oorzaken en gevolgen, door* J. A. BOOGAARD.

On the impression of the Base of the Skull, its causes and results, by J. A. BOOGAARD. *Ibid. p.* 525.

6. *De hooge oorsprong der arteria profunda femoris, door* DR T. ZAAIJER.

On the high origin of the Arteria Profunda Femoris, by DR T. ZAAIJER. *Ibid. p.* 527.

7. *Ligging der arteria anonyma aan den hals vōōr de luchtpijp, door* W. KOSTER. Deel II. 2e Aflevering, 1866, bl. 207.

Position of the Arteria Innominata in the Neck in front of the Trachea, by W. KOSTER. Vol. II. Part. 2, p. 207.

8. *Over de snelheid der gedachte en der wilsbepaling,* voorloopige mededeeling van F. C. DONDERS. Deel I. 4e Aflevering, bl. 518.

On the Rapidity of Thought and of the Determination of the Will: A Preliminary Communication by Dr F. C. DONDERS. Vol. I. Part 4, p. 518. See also *British and Foreign Medico-Chirurgical Review,* July, 1866, p. 168.

9. *Spierarbeid en warmte-ontwikkeling, in verband met de vereischte voedings-beginselen, door* F. C. DONDERS. *Ibid.* Deel I. 1e en 2e Afleveringen.

On the Constituents of Food, and their relation to Muscular Work and Animal Food, by F. C. DONDERS, M.D., Professor of Physiology and Ophthalmology in the University of Utrecht. Vol. I. Parts 1 and 2. See also *Dublin Quarterly Journal,* Vol. 41. 1866, pp. 238 and 469.

II. *Bidrag til Bedömmelsen af Födemidlernes Næringsværdi, af* Dr Med. P. L. PANUM, *Professor i Physiologien ved Kjöbenhavns Universitet. Kjöbenhavn,* F. HEGEL, 1866.

A Contribution to the Estimation of the Nutritive value of Foods, by P. L. PANUM, M.D. Professor of Physiology in the University of Copenhagen. 8vo. pp. 104.

III. *Bidrag til Kundskab om Echinococcernes Udvikling, navnlig om Döttreblæredannelsen, af* VALD. RASMUSSEN, *Prosector i patholog. Anatomi.* (*Af Naturhist. Foren. Vidensk. Meddelelser.* 1865).

A Contribution to our knowledge of the development of Echinococci, particularly with reference to the formation of Daughter-cells. By VALD. RASMUSSEN, Prosector in Pathological Anatomy. (Reprinted from the Reports of the Natural History Society of Copenhagen, 1865). 8vo. pp. 29.

IV. *Helminthologiske Undersögelser i Danmark og paa Island, med særligt Hensyn til Blæreormlidelserne paa Island. Af* Dr. Med. H. KRABBE. (*Særskilt aftrykt af det Kongl. Danske Videnskabernes Selskabs Skrifter. 5 Række, naturvidenskab. og mathem. Afdeling, 7 Bind*). *Kjöbenhavn,* 1865.

Helminthological investigations in Denmark and Iceland, with special reference to Tapeworm affections in Iceland. By H. KRABBE, M.D. (Reprinted from the Publications of the Royal Danish Academy of Sciences, 5th Series, section for natural philosophy and mathematics, Vol. VII.). Copenhagen, 1865. 4to. pp. 64, with 7 copper plates.

I. THE *Dutch Archives*, whose title stands at the head of the foregoing list, are remarkable for the number of important and practical papers upon medical and surgical subjects which they contain. Of several of these I have given translations in our Medical Periodicals. Many essays of considerable anatomical and physiological interest are also to be met with in their pages, and short notices of these from time to time will, I should hope, prove not unacceptable to the readers of this Journal.

1. The first article to which I shall direct attention is one by the distinguished Professor of Physiology and Ophthalmology in the University of Utrecht, Dr F. C. Donders, *Upon the Lingual Apparatuses of the organ of Voice and Speech.*

"Voice and Speech," observes the author, "belong to the domain of physiology. To her belongs the task of investigating the nature of vocal and oral sounds, as well as the mechanism whereby they are produced, and of explaining these sounds by that mechanism.

"The voice is the result of the vibrations of the inferior vocal chords. These are the tongues of a lingual apparatus, acting in singing as percolating, in speaking probably as opening tongues, in the thoracic voice vibrating with the thyreo-arytenoid muscle therein put upon the stretch by its antagonists, in the falsetto vibrating without this muscle. The lowest bass voice descends to $F_{,}$, the highest soprano rises to f''', so that the human voices, taken together, comprise five octaves, from 44 to 1408 vibrations in the second,—the same limits, as it happens, as those of the old five-octave pianos.

"Besides the inferior vocal chords, vibrations may be produced in different places in the organ of voice and speech in special lingual apparatuses. The tongues may be: *a.* the lips (double tongues, as the chordæ vocales); *b.* the point of the tongue; *c.* the uvula; *d.* certain parts of the larynx, situated above the true chordæ vocales. In whistling, one of the tones of the labial murmur is strengthened by resonance in the cavity of the mouth, in the same manner as in flute instruments.

"The lingual apparatuses mentioned in the organ of voice and speech agree essentially with that of the proper voice. They are to be regarded as so many voices, and give more or less distinct sounds, with a definite and in general very low fundamental tone. However they, or at least those distinguished as *a*, *b* and *c*, cannot replace the voice, because they are formed too much anteriorly, and therefore altogether, or almost altogether lose the opportunity of vocal modification of the sound and of articulation in general. They then find another employment, that of breaking off the vibrations of the voice or of whispering. Thus they appear as the consonants *r*, the tremulous sounds (Zitterlaute) of Chladni, called by te Winkel rattle-consonants. We shall therefore distinguish the forms mentioned under *a*, *b*, *c* and *d*, as r_1, r_2, r_3 and r_4."

The author divides consonants into 1°. the *explosive*, closure-sounds (*Verschluss-laute*) of Chladni, blow-letters (*slag-letters*) of Amman, produced by sudden closing or opening of the vocal canal, as strengthening or dimi-

nution of the vocal sound, with rapid and characteristic modification of the latter, often combined with a slight blow, but also recognisable when this blow is no longer heard. To these belong the whispering *p*, *t* and *k*, and the ringing *b*, *d*, and the Dutch *k*,—this last before the ringing *b* or *d*, in English *g*, as in game. 2°. The *rubbing*. These are actually accompanied by a distinctive sound, produced by a constriction of the vocal canal and strengthened by the dilatation of the thereon consequent cavity, which determines the height of the prevailing tone of the murmur. The *l* consonants, with lateral constriction, also belong to this group.

3°. The *resonants* (Bruecke), called also nasal or semivocal, arise, like the explosive, from sudden closing or opening of the oral canal, as *m*, *n*, *ng*,—with this difference, that the nasal canal, in place of being likewise closed, affords a passage to the air and becomes one with the cavity of the throat and mouth. Thus the vocal sound may be maintained, as the so-called growling voice (*Brummstimme*). The resonants are distinguished from other consonants by this, that in loud speaking they are *always* produced with a vocal sound (if they are not *entirely* left out, as the *n* is by many at the end of words). We are not however justified in considering them as vowels or as half vowels. As an independent sound they are better distinguished without than with accompanying vocal sound.

4°. The tremulous sounds (*Zitterlaute*) of Chladni, already defined above, distinguished as r_1, r_2, r_3 and r_4. These form the subject of the author's special investigation in the present paper. They are R_1, r_1 or labial *r*. This may be produced in two ways: *a*, as vibration of the two lips together, the broad r_1; *b*, as vibration of the middle, or of a lateral part of the lips, the slender r_1.

R_2, r_2, lingual *r*. This is the most perfect, and probably also the most used rattle-consonant. It may, however, be heard also as an independent vibration. To produce it the point of the tongue is applied upwards against the palate, while the edges of the organ are placed laterally against the inner and under surface of the teeth of the upper jaw, so that the air, driven forward through a low groove between the palate and the raised and broadly expanded tongue, causes the elastically tense point of the tongue to yield and to strike back upon the palate. We have here therefore a simple upstriking lingual apparatus. Elastic tension of the point of the tongue by tonic muscular contraction is one of the conditions of the development of r_2, and in this condition lies the difficulty that many find in the production of it. Too strong pressure gives rise to the blow-consonant, too weak without tone of the point of the tongue produces the friction-consonant *th* of the English, while in both cases the point of the tongue pushes somewhat forward.

R_3, r_3, uvular *r*. This is incorrectly looked upon as a defect. It is used by many, perhaps by the majority, and is, when well pronounced, scarcely to be distinguished by the ear from the lingual *r*. It is, however, more frequently than the latter modified by a defect. The lingual *r* is either quite pure, or on the whole not pronounced; the uvula *r* is often heard impure. Then occurs the so-called lisp (*brouwen*, *grasseyement*, *rhotacismus*), which is to be considered as a defect. The peculiar diffusion of the use of r_3 and of its impure pronunciation is remarkable. I find its use in the Netherlands connected chiefly with particular families. The impure pronunciation occurs rarely outside the town of Nijmegen, where it is almost universal, as well as in Provence. How far a congenital conformation of the mouth, or how far imitation may be the cause of this, I cannot decide.

R_4 is easily produced. If we sing as low as possible, and endeavour to go still lower, a growling sound arises, which Bruecke looks upon as the *r*

or rattle-consonant of the Lower Saxons. With a greater number of vibrations it is the Ain of the Arabs. Various opinions have been entertained as to the seat of its development. Professor Donders shows that this is at least not in the true chordæ vocales. He is able to produce r_4 at the same time with the voice, and now the tone of the voice determines the tone of r_4, which is heard an octave or a duodecime lower than the voice.

The object of Professor Donders' communication is, however, to make known his observations on the rapidity of the vibrations which belong to the rattle-consonants, and the number required in the pronunciation to enable the ear to catch it as determined by the phonautograph. For these observations, and for the woodcuts and immediate results of the phonautograph, introduced into the text, I must refer to the original paper.

2. Dr P. Q. Brondgeest communicates to the same number of the *Archief* a paper *On the Influence of Chloroform on the Action of the Heart, on Respiration, and on the Pressure of the Blood in connexion with division of the Nervus Vagus and with Curare-poisoning.* From this paper the author draws the following conclusions.

"1. The inspiration of chloroform exercises a remarkable influence on the frequency and strength of the pulsations of the heart. In the first instance it prolongs the rhythm of the latter, which subsequently becomes accelerated, this acceleration continuing until death, while simultaneously with this acceleration a diminution in the strength of the heart's action occurs.

"2. These phenomena take place, whether the chloroform be inhaled through the mouth or through a tracheal fistula, provided only that it be administered in sufficient quantity. Small quantities of chloroform, administered during a very long time, exercise no distinct influence on the action of the heart.

"3. The pressure of the blood diminishes, from the beginning of the chloroform inhalation until death: both in the prolongation and in the subsequent acceleration of the pulsations of the heart it becomes much less than before the inhalation of the chloroform.

"4. After curare-poisoning a prolongation of the pulsations of the heart likewise occurs, and the cardiac pulsations speedily become very weak, so that death rapidly ensues, sometimes with increasing prolongation, sometimes with a degree of acceleration.

"5. After dividing the two nervi vagi we observe, in chloroform inhalation, a slow, uniform diminution of the pulsations of the heart. No suddenly remarkable diminution of the pulsations occurs. Death ensues very rapidly.

"6. The respiratory movements become, just like the cardiac pulsations, suddenly retarded, and subsequently, about simultaneously with the cardiac pulsations, again accelerated. They cease before the movements of the heart.

"7. After division of the nervi vagi the respiratory movements often cease suddenly for half a minute. After this they again return more quickly.

"8. Among the causes of death, after the use of chloroform, paralysis of the heart's action occupies a prominent position. The chloroform inhaled has a paralysing effect either on the muscles or on the nervous centres of the heart, whence the rhythmical contractions proceed. The contractions of the auricle cease at a later period than those of the ventricle.

"9. When the movement of the heart has nearly ceased, the most

certain means of again exciting it and of preventing death, is the prolonged continuance of artificial respiration.

"10. When during chloroform-narcosis the two nervi vagi are divided, no remarkable acceleration of the heart's action is perceptible, but it continues until death less than before the division of the nervi vagi." pp. 473—498.

3. Professor Ermerins contributes a paper on *Irradiation on Symmetrical Parts of the Opposite Side*, which, though really pathological, is, as the author justly observes, more interesting to the physiologist than to the practitioner. It is, in fact, by studying the pathology of the nervous system that we learn much of its physiology. The loss or alteration of certain functions, taken in connexion with lesions of its different parts, throws, of course, much light upon the functions of those parts. The author's attention was directed to the subject of his present paper by the observation of a case of paralysis of the lower limbs, occurring in a man aged 53. This patient was accidentally burned on the inside of the left thigh, by the incautious application of a hot water jar. When this occurrence was discovered a day or two later, the patient felt *pain not only in the burned part of the left thigh,* but also, though less violently, *in the corresponding part of the right thigh.* This pain lasted for some days, and ceased when the burn was healed. The painful part of the right thigh exhibited neither change of colour of the skin, swelling, nor anything unusual. The post mortem examination revealed atrophy of the brain and of the spinal cord, with asymmetry of the hemispheres of the cerebrum, the left preponderating, and softening of the cerebellum.

Five other cases of this nature are on record:

1°. One by Boyer (*Traité des maladies chirurgicales.* T. VII. p. 9), quoted by Schiff (*Lehrbuch der Physiologie des Menschen*). The patient, a drummer, received from a drunken comrade a sabre-wound in the upper and back part of the right side of the neck. The wounded man immediately felt his legs give way under him and fell. On admission to hospital next day it was found that the right arm had lost the power of motion, but retained its sensibility. The right leg seemed a little weakened, but was as sensitive as usual. On the thirteenth day there was still paralysis of the upper extremity. In playing with one of the attendants who pinched him, the patient perceived that the left side of his body was insensible. On examination it was found that "the left leg and the left side of the trunk preserved the usual size, movements, and activity; but we could pinch, prick, and even cut the skin, without the patient feeling or exhibiting the slightest pain; pins were inserted to the depth of three or four lines, without being perceived. Extensive touches, however—such as the application of the flat hand moved along the skin—caused the patient to experience a kind of sensation, though extremely obscure and slight. This insensibility existed throughout the entire extent of the left foot, leg, and thigh; it was equally complete on the left side of the abdomen; but it ceased abruptly before and behind the median line, *with this remarkable peculiarity, that in this part, if the patient were pinched on the left side, he asserted that he felt the sensation in a slighter degree at the corresponding part of the right side.* A similar demarcation between the right and left side extended to the skin of the penis and scrotum. The insensibility was equally complete at the left side of the base of the chest, but a little higher up a dull sensation began to be perceptible, and became more manifest in proportion as we examined upwards, so that at the height of the fourth rib the skin was as sensitive as that of the rest of the body. The left limb was in a perfectly natural state." Boyer remarks upon this case that

"the situation of the wound, and the symptoms by which it was accompanied, would lead us to infer that the spinal marrow was engaged, but that it must have been only superficially so."

2°. Treviranus (*Biologie*, v. p. 370) "knew a lady, in whom a blister applied behind one ear invariably at the same time gave rise to pain behind the other."

3°. Van Deen wrote to Schiff respecting the case of a lady who had been attacked with apoplexy, which left behind it anæsthesia and acinesia of the left side. In this state, on the application of a stimulant (oil of mustard) to the insensible arm, pain was felt by the patient in the arm of the opposite side.

4°. Van Deen told Professor Ermerins also that he had observed something similar in a sufferer from paralysis of one of the lower extremities: namely, on peripheral irritation of the anæsthetic leg a painful sensation occurred in the other.

5°. Partly in accordance with this is what a doctor of surgery related to van Deen: a patient had undergone amputation of the thigh; the fresh wound was touched in a place where a nerve had been divided. Thereupon pain was felt both in the part touched and in the corresponding point of the opposite side.

6°. The case related by Professor Ermerins, and which led to his writing the paper of which I here present an abstract. To sum up: in Boyer's case there was traumatic injury of the spinal cord. Of van Deen's two cases, in one apoplexy, in the other anæsthesia resulted from a central affection. In the case observed by Professor Ermerins an abnormal state of the brain, cerebellum, and spinal cord existed. We have consequently four cases where the phenomenon occurred under pathological conditions of central parts, though these conditions were outwardly different. In the case related to van Deen, the communication of the painful sensation to the other side occurred after an operation, which, from the violence of the shock, must almost necessarily produce a difference in the functional condition of the spinal cord and brain. The case so briefly touched upon by Treviranus is therefore the only one which gives no information on this subject.

In conclusion, Professor Ermerins says:

"From what has been observed I would therefore almost positively venture to lay down that, in order to produce transmission of sensory impressions to the opposite side, certain unknown abnormal conditions of the central parts are necessary. There is no doubt that in the healthy state such transmission does not take place.

"Schiff appears in the above quoted place to refer to an anatomical connexion between the sensitive parts of the right and left side of the spinal cord. Even if this exists, it is certain that in the regular function of the parts the connection does not manifest itself in outward phenomena, and that consequently the left and right sides are functionally distinct. Under extraordinary circumstances this distinction is removed. As to the nature of these circumstances we know nothing, but they are to be sought in the spinal cord. Perhaps a certain unusualness and violence of irritation is necessary, in order, in this state of the central parts, to enable the transmission to be effected. The sensory nerves appear to me to remain capable of conduction even where anæsthesia is present. The peripheral impression received by them does not reach the consciousness, but must in reality exist, and must act through the nerve upon the central part;—how should the transmission of the impression to the opposite side otherwise be possible? If in the central parts those conveying sensation to the other side have come into action, this action must, according to the law of

eccentricity, be transmitted to the periphery. This is all that I, at least, can suggest upon the subject.

"Whether, moreover, the phenomenon is as rare, as the little mention made of it would lead us to suppose, is doubtful. I imagine that it often occurs, without being observed, and that it is often observed without sufficient importance being attributed to it to cause attention to be particularly directed to it. Physiologists attach more importance to such matters than practitioners do, and the latter have more opportunities than the former for making such observations."

Of the foregoing paper I have given a translation in full in the *Medical Press and Circular*, July 11, 1866, p. 37.

4. The next paper on my list is an abstract of one which originally appeared in the *Ned. Tijdschrift voor Geneeskunde* for 1865, on the third condyle of the occipital bone, first described by J. F. Meckel, which sometimes occurs on the inferior surface of the basilar part, and which was accurately examined by H. J. Halbertsma in a number of skulls, especially in some derived from the East Indian Archipelago. The latter writer distinguishes, with respect to the mode of origin, various forms. In the first place there may occur in front of the anterior margin of the great occipital foramen a conical projection, articulating either with the odontoid process of the dentata, or with the anterior arch of the atlas; subsequently lost among the "double middle articulating processes" (which H. calls *processus papillares*), and so forming a third condyle.

Further, H. has observed and delineated cases, where the papillary processes coalesce with the lateral condyles. Moreover, the very important peculiarity occurs, that papillary processes are found on the *inferior surface* of the basilar part, together with a third condyle *at the anterior* margin of the great occipital foramen (represented pl. vi. fig. 2). Halbertsma supposes that the last little tuberosity, which has a smooth, flat top, has been connected with the odontoid process of the dentata; it would then have formed a true third condyle. So long, however, as the skulls, with such unusual occipital articulations, have not been examined in connexion with the corresponding vertebræ, the proper signification of the tuberosities is not to be ascertained. If Halbertsma's opinion be correct, this observation of his quite agrees with the idea recently given by Koster (*Nederlandsch Archief*, 1864, Afl. 3, pp. 374, 375), respecting the morphological signification of the two superior cervical vertebræ and of the occipital bone. The conformation almost completely agreeing with an anterior arch of the atlas, proceeding from the connexion of unusual tuberosities with the lateral tuberosities, and between which and the basilar part a space exists (delineated by Halbertsma, pl. viii. fig. 2), forms a sort of hæmal arch. On the other hand such a portion of bone (as little as the tuberosities represented in pl. vi. fig. 1, and pl. vii. fig. 2, on the *under surface* of the basilar part) can scarcely have articulated with the odontoid process, but may probably have done so with the anterior arch of the atlas.

The peculiar connexion of the vomer with the second cranial vertebra leads Halbertsma to think that this bone too must be considered as an hypapophysis (rather hæmapophysis, as in ordinary nomenclature hypapophysis is not used with reference to the anterior vertebral arch).

It is remarkable that the unusual tuberosities on the basilar part of the occiput are found most frequently in skulls of Malays.

5. An abstract is given of J. A. Boogaard's paper *On the impression of the base of the skull, its causes and consequences.* In our preceding number, say the Editors of the *Nederlandsch Archief*, we mentioned the dissertation of Bogtstra, in which he treated of the impression of the base

of the skull. Prof. Boogaard examined this subject still more fully, and communicated the results of his investigation in the *Nederlandsch Tijdschrift voor Geneeskunde*, 1865, 2. afd. p. 81. He first gives an historical retrospect, and communicates the cases described by Retzius, Berg, Lucæ, Davis &c.; after which he reverts to the skulls contained in the Anatomical Museum at Leyden, and already described by Bogtstra. The measurements and anatomical peculiarities are there stated more in detail, especially the varying form of the foramen occipitale magnum, the margin of which, instead of an oval, describes a very irregularly curved line.

A geometrical construction of the different angles to be measured on the skull, and a representation of the instrument with which Boogaard measures his basal angle, make all very plain.

None of the hydrocephalic skulls examined by Boogaard exhibited the impression of the base, so that hydrocephalus does not belong to the remote causes of the impression of the skull.

Among the proximate causes we observe especially atrophy of the osseous tissue, and fatty degeneration. These are almost always to be met with in skulls with impressed base.

It now depends upon the extent and the more or less symmetrical nature of the affection of the bone, what *form* of impression shall occur. If only a small portion of the bone in the immediate neighbourhood of the foramen magnum be impressed, the *position of the clivus* in particular undergoes important changes and becomes more horizontal. On the other hand the whole body of the sphenoid bone, with the basilar part of the occipital and the adjoining parts of the temporal bones, may be pressed directly upwards, whereby the relative position of the parts is often little altered.

In children the impression of the skull is not observed, but with this exception it occurs at any time of life.

It has seldom been possible to ascertain whether the impression of the base of the skull has produced any, and if it has, what results during life. From a few cases it may be inferred, that morbid phenomena are not necessarily excited by it. Boogaard himself, however, observed a case, treated by Dr Frenay during life, in which the impression was evidently attended with symptoms of disturbed cerebral function. In this person after the fortieth year of life difficulty in moving the voluntary muscles set in. This increased, and soon the man could not go up stairs without holding on both sides; subsequently he fell about often even on the level ground. The cause of this was not direct diminution of muscular power, but inability to coordinate and regulate movements. Subsequently symptoms of paralysis of the pharynx and of some of the muscles of the face with difficulty of speech set in. For a few weeks before his death the man was drowsy, restless, and delirious.

On opening the body Boogaard found in this case the impression of the base of the skull described at length by him, and at the right side of the cranial cavity on the inner surface of the dura mater a great quantity of effused blood. The lateral ventricles were distended with serum, the septum lucidum had almost entirely disappeared, the basilar artery was deeply impressed into the pons Varolii. The left abducent nerve, and the right facial and auditory nerves, were atrophied and softened.

In such cases it would probably be possible, if they depend upon a considerable symmetrical impression of the base of the skull, to arrive at a diagnosis thereof during life, by the shortening of the neck and a slight lordosis. The asymmetrical impression of the skull on the contrary gives rise to no changes, by which it may during life be with probability suspected.

6. *On the high origin of the Arteria Profunda Femoris*, by Dr T. Zaaijer. The writer examined a case of division of the external iliac artery, immediately below Poupart's ligament, into two nearly equal branches. One of these was continued as arteria femoralis, the other as profunda femoris. From the latter sprang the arteria circumflexa externa, at 3·5 centimètres (= 1·3779″) below Poupart's ligament, while the arteria circumflexa interna was wanting. On the other hand, the arteria perforans prima was more highly developed than usual. The arteria epigastrica Halleri arose independently from the arteria profunda.

In view of this case, the author proceeds to inquire which place of origin of the arteria profunda femoris is to be considered normal. This place varies from one inch above Poupart's ligament (Hyrtl) to four inches beneath it (Gray and Quain). From the statistical statements of the writers which he quotes, Zaaijer comes to the conclusion, that as a rule we must set down the origin of the arteria profunda at from $1\frac{1}{2}$ to 2 Parisian inches below Poupart's ligament.

In the case examined by Z. the origin of the arteria profunda lay to the outside of the external iliac artery. Statements differ very much as to the seat of origin, even in the cases where the profunda arises at the ordinary height from the femoral artery. According to some this artery arises at the outside, according to others from the inside of the main trunk. The truth is that both cases occur, and Zaaijer coincides in the explanation given by Srb[1], that the place of origin of the profunda depends upon whether it gives off the internal circumflex. Then the seat of origin lies more to the inside, while in the opposite case the external circumflex artery, as it were, draws the profunda outwards (?).

From the cases recorded in literature it appears, that such a high origin of the arteria profunda femoris is exceptional. The practical importance of this is evident. In such a case we should, tying the femoral artery at the usual height, with a view to apply the ligature *above* the arteria profunda, find our object frustrated, while in some cases it may thus become necessary to tie the iliac artery instead of the femoral.

7. *Position of the Arteria Innominata in the Neck in front of the Trachea*, by W. Koster. Although the modifications in the number, course, and situation of the arteries arising from the arch of the aorta, appear capable of no further increase, I lately observed a deviation of the innominata which, on account of its surgical importance, deserves mention.

In preparing the cervical region of a woman, aged 75, whose arteries were injected with gelatine, we discovered that above the jugular notch of the sternum, beneath the sternohyoid and thyroid muscles, a tumour was perceptible, situated in front of the windpipe. In the neck covered by the skin nothing abnormal was observable; nor did the prepared anterior superficial cervical muscles exhibit any abnormity in position or course.

On closer examination an artery was seen beneath the muscles just mentioned, so thick that at the first glance we thought we had before us the whole arch of the aorta. It appeared, however, that the arteria innominata arose in this case precisely in the median line, just under the jugular notch of the sternum, and ran nearly three centimètres (1·1811″) above the sternum directly in front of the trachea, in order then, bending to the right, to divide into the two well-known branches. The common carotid artery therefore made first a transverse curve, to ascend subsequently

[1] J. Srb, Ueber das Verhälten der Art. profunda Femoris; in *Oesterreichische Zeitschrift für praktische Heilkunde*, 1860. No. 132.

in the usual way; the subclavian artery descended in an arch. Quite close to the innominata arose the common carotid artery.

The ascending portion of the aorta was, from the ostium arteriosum to the origin of the innominata, $7\frac{1}{2}$ centimètres (2·95281″) in length. The entire innominata was 4 centimètres (1·574832″). The arch of the aorta lay high, was atheromatous and ossified, dilated about one half more than in the normal state.

On one other occasion I observed a perfectly analogous condition in a man aged 40. The portion of the innominata, which in this instance lay in the neck in front of the trachea, had, however, a length of only $1\frac{3}{4}$ centimètres (·688989″) above the jugular notch of the sternum.

We have here evidently to do with a congenital abnormal position of the arteries. The whole aorta lies too much in the middle line. The innominata, which in ordinary cases arises a little to the right of the middle line, and immediately turns obliquely to the right, so that it runs not along the middle of the sternum, but along the posterior surface of the sterno-clavicular articulation, here runs straight upwards.

It is at once apparent, how dangerous in such cases wounds in the lower part of the neck would be, and how tracheotomy above the sternum becomes an impossibility, as the artery reached to the inferior margin of the thyroid gland, unless it probably might be pushed aside. It is, however, a question, whether it would be possible without injury to continue the latter proceeding for days together, as must be done in applying and securing the tube, &c.

It seems that such an anomalous course of the arteria innominata has not hitherto been described. At least we do not find it mentioned by Tiedemann. It is indeed true that the trachea, just above the sternum, is occasionally crossed obliquely by a left carotid, arising as a third branch from the innominata at the right side. The closest analogy to the abnormity just described, in a surgical point of view, is presented by the cases communicated in Tiedemann, where from the arch of the aorta, right and left, a subclavian artery arises, and in the middle a common branch for the two carotids, which then runs up for a short way in front of the trachea, before it divides. This anomaly is to be considered as an "animal type," as it constitutes the usual condition in the elephant; and moreover, according to Dr Bernstein, occurs in an East Indian bird (Pitta cyanura Vieill.), where the common trunk runs too high up in the neck, in order then to divide into two, that which arises on the left passing to the right, and *vice versâ*.

8. Professor Donders instituted experiments to determine the rate of conduction in the nerves, and, more particularly the time required for the formation of a definite idea, and for the expression thereof through the organs of the will. The physiological time T is the time which elapses from the acting of a stimulus upon the peripheral nervous system to the giving of some signal. T is greater on irritation applied to the foot than on irritation in the groin; the difference is the time required for conduction in the nerve from the foot to the groin. In order to determine T in impressions of sound, the phonautograph was used as a chronoscope. Of the short paper, which is only preliminary, I have given a translation in the July number of the *British and Foreign Medico-Chirurgical Review*. I have to acknowledge the author's kindness in correcting a proof of the translation.

9. Professor Donders contributes to the first and second parts of the first volume of the *Archief*, an important paper upon the constituents of Food and their relation to Muscular Work and Animal Food, which he

has also published in the form of an octavo pamphlet of 74 pages. This valuable essay I have translated *in extenso* in the 41st volume of the *Dublin Quarterly Journal*, February and May 1866. The bearing of the essay is concisely summed up by the author in the following *conclusion:* Muscular work and heat arise in the animal organism, both being derived from the chemical energy as well of non-nitrogenous as of nitrogenous matters. Of both kinds of food the animal system has need. In the body there exists a certain relation between heat produced and muscular work. By exercise this relation becomes most favourable for muscular work. A liberal supply of albuminous matter tells favourably in the same. The reason of this is probably to be found in the better nourished and firmer condition of the muscles and of the whole body, which is obtained by means of a more highly albuminous diet. The development of man in general appears to attain the highest pitch under the use of a mixed diet.

II. To the number of the *British and Foreign Medico-Chirurgical Review* for July, 1866, (p. 83), I have also contributed a notice of the interesting work of Dr Panum, Professor of Physiology in the University of Copenhagen, upon *The Estimation of the Nutritive Value of Foods.* The author presents the results of his investigations in a series of tables. The length to which this article has already run obliges me to refer to the *British and Foreign* for the details of some of his results. I shall here mention only those contained in his fifth table, upon the histogenetic value of different kinds of bread and groats. Of the breads, Nielsen's strengthening bread (Kraftbröd), prepared with additional gluten, takes the first rank; French roll, baked, at the author's request, with blood instead of water comes second; the less white and less well-looking French roll from an inferior baker takes the third place; while the very nice-looking, white and well-tasting French roll from the court baker appears to have the least histogenetic value. The latter circumstance is probably due to the fact, that the meal derived from the centre of the wheat, which is remarkable for the beautifully white appearance of the bread made from it, is much poorer in gluten than that procured from the outer layer. The author expresses surprise that the histogenetic value of the bread baked with blood was scarcely greater than that of the French bread from an inferior baker, a fact which he thinks is probably to be attributed chiefly to the albuminous matters of the blood losing, at the high temperature employed in baking, a portion of their original nutritive power. In a note he alludes to a prevalent opinion that the common dark rye-bread must be particularly nourishing, as it contains the meal next the husk, which abounds in gluten. He shows, however, that this is not the case, but that the dark rye-bread is undeniably the worst of all kinds of bread.

Professor Panum instituted a series of experiments to test the nutritive value of a new substance introduced into commerce from the starch manufactory of C. Nielsen, under the name of household or gluten groats. This consists of flour kneaded with the gluten of an equal quantity of flour, dried and ground into groats. In this case, too, it was found that the histogenetic value of the dough was essentially lessened by the heat employed in the drying of the mass.

In the case of French gluten meal, also, used for bread for diabetic patients, the histogenetic value calculated from the amount of urea produced was less than would, *à priori*, have been expected. Here, too, the drying of the meal seems to have been the cause of the difference, the albuminous matters having been rendered thereby less capable of solution in the digestive fluids.

III. Dr Rasmussen, in the work quoted in the heading of this article, treats of development and natural history of the echinococci from a zoological point of view. His essay may therefore claim some brief notice here.

The old controversy, whether echinococci ought to be referred to one or two species, which was again brought forward by Küchenmeister when he divided them into *E. scolecipariens* and *E. altricipariens*, corresponding to the older classes *E. veterinorum* and *E. hominis*, seems to have been at last decided by Naunyn and Krabbe having, about contemporaneously, succeeded in causing scolices of the human echinococcus to be developed in the intestines of the dog to *tænia echinococcus*, in the same time and in the same mode as was first demonstrated in 1852 by von Siebold with the echinococcus of the ruminants (*E. scolecipariens*).

The author's investigations confirm the view so strongly put forward by Leuckart, that the scolex-formation always proceeds in brood-capsules developed from the parenchymatous layer of the mother-cell, and being in continual connection with the same. The daughter-cells are formed either endogenously or exogenously with respect to the mother-cell, but these two forms are not strictly separated, and may often be developed together: in cells which are developed endogenously, new cells may be again produced both endogenously and exogenously. The endogenous cell-formation proceeds exclusively from the brood-capsules.

Brood-capsules sometimes occur containing only one scolex. These capsules are developed in the same manner as those containing many scolices.

As to the signification of the daughter-cell formation in general, it may be assumed that it does not indicate a progressive development of generations, for scolices in the daughter-cells do not exhibit any other than individual differences from those which are formed in the mother-cells; all scolices in a compound echinococcus cyst are equally adapted for development, under certain conditions, to the state of *tænia echinococcus*.

IV. The object of Dr Krabbe's work, which comes before us in the form of a handsome quarto volume, illustrated with seven well-executed copper-plates, is, as we are informed in the opening paragraph of the preface, to ascertain the source of the so-called hydatid disease endemic in Iceland, with a view to discover how far and by what means its occurrence may most advantageously be prevented.

"Eschricht's investigations have shown that this affection consists in the development of echinococci-cysts in the different organs of the body, and as it occurs not only in Iceland, but also sporadically in other countries, and among these with us, it was to be expected that the corresponding tapeworm should, on careful examination, be found with us also. From the discoveries recently made with reference to the development of hydatid tapeworms, it was to be inferred that the dog, and possibly the cat, harboured this parasite. Partly with the hope of finding it in this country, partly also in order to become better acquainted with the occurrence of intestinal worms in general in these two domestic animals, and so to obtain a basis of comparison with the corresponding state of things in Iceland, I have, in the course of many years, examined in the Royal Veterinary and Agricultural College, a great number of dogs and cats." p. 3.

Some of the author's statistics may not be uninteresting in a Zoological point of view. The first section of his work is devoted to "Entozoa in the intestinal canal in the dog and cat in Copenhagen." During the years 1860—63 he examined 500 dogs of various sizes and ages, from some months to 17 years old, which were brought in to the institution already mentioned, either dead of disease or for the purpose of being killed. Among these 500, intestinal worms were met with in 336 or in 67°/°.

Tænia marginata	occurred	71	times or in	14 °/₀
...... *cœnurus*	„	5	„	1
...... *serrata*	„	1	„	0·2
...... *Echinococcus*	„	2	„	0·4
Tænia cucumerina	„	240	„	48
Bothriocephalus Sp.	„	1	„	0·2
Ascaris marginata	„	122	„	24
Dochmius trigonocephalus		9	„	2

Of cats he examined in the years 1861—64, 100, for the most part aged, which were brought in to be killed, only a few had died of disease. In 78 of them intestinal worms were met with, viz. *Tænia crassicollis*, 5 times; *Tænia elliptica*, 57 times; *Bothriocephalus Felis*, twice; *Ascaris mystax*, 55 times.

In Iceland the author examined, in addition to the dogs which served for experiments by feeding, and 17 dogs on which the effect of anthelmintics was tried, some few pups, and 100 dogs over a year old. In 93 of these entozoa were found in the intestinal canal, viz.:

Tænia Marginata, 75 times.
...... *Cœnurus*, 18 times.
...... *Echinococcus*, 28 times.
...... *Cucumerina*, 57 times.
...... *Canis Lagopodis*, 21 times.
Bothriocephalus fuscus (*stricte, reticulatus* and *dubius*), 5 times.
Ascaris Marginata, twice.

In 31 cats, intestinal worms were discovered 25 times, or in 81°/₀, viz.: *Tænia crassicollis*, 7 times, or in 23 per cent.; *Tænia Canis Lagopodis*, 11 times, or in 35 per cent.; *Ascaris Mystax*, 16 times or in 52 per cent. Towards the close of his volume, the author details some carefully performed experiments, which, in his opinion conclusively prove that the *Echinococci* of man, as well as those of animals, are developed in the dog to the state of *Tænia Echinococcus*, whence it would necessarily follow that both owe their origin to the ova of the tapeworm.

Dr Allbutt (*Proc. of Med. Ch. Soc.* v. 193) gives a case of PREMATURE MENSTRUATION in a child 1½ years old. It occurred with regularity each month; and its exhausting effects proved fatal after the fifth time. Exhaustion and death have been the result in the other cases of the kind that have been recorded.

Dr B. W. Richardson stated, in the Physiological Section of the British Association at Nottingham, that a nerve paralysed as to its conductive power of motion or sensation by the ether spray, still transmits electric currents; and he believes that electric currents and nerve currents have very little relation to one another, and that the part played by electricity in the animal functions, especially the nervous and muscular, has been much overestimated.

Mr J. B. Lawes and Dr J. H. Gilbert, in a paper read at the British Association, draw the following conclusions from a number of experiments made by them. Certainly a large proportion of the fat of the herbivora fattened for human food must be derived from other sources than fat in the food. When fed on the most appropriate fattening food, much of the

stored-up fat must be produced from the carbo-hydrates. The nitrogenous constituents may also serve as a source of fat, more especially in defect of a liberal supply of the non-nitrogenous ones.

PSYCHOLOGY OF THE GREEKS. From a paper on Plato's *Theætetus*, read before the Cambridge Philosophical Society, May 31st, 1866, by E. M. Cope, Fellow of Trinity College. All the old philosophers identified, or at any rate did not distinguish, thinking and sensation or feeling. The alleged separation of mind and matter, first introduced into philosophy by Anaxagoras, was but a crude conception never applied in detail, stopping short at the very commencement and leading to no further research or analysis. Protagoras, with all his versatility and manifold accomplishments, was not in advance of his age in psychological knowledge, and like his contemporaries made no distinction between thinking and feeling. Socrates was far too busily engaged with his ethical generalizations to bestow any time or attention upon psychological investigation. The discussion in the *Theætetus* of Plato is interesting as the earliest attempt remaining to classify psychological phenomena. In it is suggested or implied a division of three modes of apprehension of things, viz. sensation; opinion or belief, which is fallible, liable to error, never rises beyond probability, and is derived from sensation and memory; and knowledge, *ἐπιστήμη*, which is constant, universal, and infallible; and to these modes of apprehension, or mental operations or processes, special faculties must necessarily correspond.

The passage in which Protagoras' view of the mode and the objects of apprehension is most clearly set forth occurs in *Theæt.* 161. C, where Socrates expresses his wonder that Protagoras had not made a pig or a dog-faced baboon, or any other out of the way (*ἄτοπον*) creature, his measure and standard instead of man; any animal *τῶν ἐχόντων αἴσθησιν*—from which it would seem that *αἴσθησις* according to Protagoras is common to all animals, and *therefore* excludes all thought and all purely intellectual action. In like manner Aristotle, *de Anim.* II. 2, distinguishes animal from vegetable by the attribute of sensation: nothing being entitled to the name 'animal' which has not at least the sense of touch, though some animals want even the power of motion. Vegetable, the lowest form of life, is distinguished by the possession of the nutritive faculty alone. This induces him to reject the opinion of Plato, who ascribed *ἐπιθυμία* to plants: this, he says, would involve pleasure and pain, and sensation or feeling in general, which is the very thing that distinguishes animal from vegetable. *περὶ Φυτῶν*, I. 1. 3.

Mr H. Seeley, of Sidney Sussex College, read a paper, the result of much thought and study, at the Cambridge Philosophical Society, Feb. 26, 1866, on a NEW THEORY OF THE SKULL AND THE SKELETON. As a necessary preliminary enquiry he considered the theory of a simple ossification and the mechanical forces—pressure and tension—acting upon bones during their growth, regarding secondary ossifications or epiphyses as regulated by them. His view of a vertebra corresponds with that usually held. The brain-case he regards as consisting of one vertebra of which the basisphenoid is the centrum, the lower jaw the rib and the other parts the epiphyses.

We have received from Prof. Van der Hoeven of Leyden a note on the CARPUS and TARSUS of the CRYPTOBRANCHUS JAPONICUS, which he has lately had an opportunity of dissecting. He finds the carpus to consist of

eight cartilaginous pieces, viz. three in the first row—a 'radial' or scaphoid, an 'ulnar' or cuneiform, and an 'intermediate' or semilunar—; four 'carpals' in the second row, corresponding with the trapezoid, magnum and cuneiform and bearing the four corresponding metacarpals; and a large 'central' piece articulated with the radius and all the other carpal bones except the trapezoid. In the tarsus are ten pieces, viz. three in the first row—a 'peroneal' or os calcis, a 'tibial' and an 'intermediate' corresponding with the astragalus—; five 'tarsals,' corresponding with the three cuneiform and the cuboid and bearing the five metatarsals; and two 'central' pieces, of which one corresponds with the scaphoid. The presence of two 'central' pieces in the tarsus is, so far as we at present know, peculiar to this gigantic batrachian. Although the carpus and tarsus were cartilaginous the metacarpals and metatarsals were fully ossified.

THE VENÆ INNOMMINATÆ ENTERING THE RIGHT AURICLE SEPARATELY, AND EACH JOINED BY A VENA AZYGOS.

THE specimen of this interesting example of the persistence of a fœtal condition was dissected and sent to me this summer by my friend and former pupil, Mr A. Godson, of Trinity College.

The right vena innominata pursued the ordinary course of the superior cava to the right auricle, being joined, as usual, by the vena azygos, which ascended on the right side of the aorta, receiving the right intercostal veins and turning over the right bronchus.

The left vena innominata, instead of passing across to join the right, descended in front of the arch of the aorta and the left pulmonary artery vein and bronchus, then passed behind the left auricle, forming part of its wall, across to the right auricle, into the back of which it opened. The orifice, which was large, was situated between the lower margin of the valve of the foramen ovale and the opening of the coronary vein[1]. There was no trace of the valve of Eustachius.

A left and smaller azygos vein ascended along the left side of the aorta, receiving the left intercostals and crossing forwards over the arch of the aorta, joined the left innominate vein.

The similarity of this variety to the usual arrangement of the veins in birds and reptiles is obvious. In them the two precaval veins, the homologues of the innominates, descend to the auricle, each receiving a vena azygos. The azygos veins, or their homologues the vertebral or cardinal veins, are in fishes of much larger size, commencing at the tail-fin and receiving, as they pass forwards, the blood from the osseous and muscular segments; and each joins the jugular of its side forming the precavals. In the higher classes they are reduced in importance in consequence of the inferior or posterior cava receiving much of the blood from the vertebral segments as well as from the hinder limbs and pelvis.

Thus in fishes the blood of the right and left sides of the trunk and head is conveyed, symmetrically, by the respective separate precaval veins to the auricle. In reptiles and fishes the symmetry disappears posteriorly, the blood of the two hinder limbs and the *hinder* part of the trunk being conveyed by one—the 'post caval'-trunk—to the heart; while the blood of the right and left sides of the *fore* part of the trunk head and the fore limbs reaches the heart, symmetrically, by the respective right and left precavæ.

[1] In the bird the precaval passes behind the left auricle on its way to the right, as in this instance, and receives the coronary vein, which has not, therefore, as it had in this specimen, and usually has in mammals, a separate opening into the auricle.

In mammals symmetry is lost in front as well as behind; the streams of the left side of the fore, as well as of the hind part, crossing to the right before reaching the heart: the left azygos joining the right behind the heart, and the left innominate joining the right in front of it. In the specimen under consideration, therefore, and in the early fœtal disposition, of which it is a persistence, we have the symmetrical disposition of the veins retained in front, while it is lost behind, which is a resemblance to the avian and reptilian rather than to the piscine characters.

The only point in which the specimen differed from the fœtal disposition of the veins, as described by Kölliker and others, is in the left innominate or precaval, having an opening separate from that of the coronary vein, whereas in the fœtus the coronary usually opens into the precaval; and while, in course of development, the remainder of the precaval becomes obliterated, its terminal part remains as the terminal part of the coronary vein.

The cause of the arrest of the ordinary process of development in this instance was not obvious. The transfer of the current of the innominate blood from the left precava behind the auricle to the right precava, and the obliteration of the left precava as well as the upper part of left azygos, which take place in the ordinary course of the development of the fœtus, is probably due, in part at least, to the pressure exerted upon the left precava by the increasing size of the left auricle, which we may suppose obstructs the flow of blood through it, and causes it to be diverted through a communicating vessel (the left innominata) in front of the aorta to the right vena cava. In the bird and reptile this obstruction and consequent diversion of the current do not take place because the left auricle remains in them of comparatively small size. Whether the more oblique direction of the heart in mammals as compared with birds and reptiles has any effect I cannot say. In this specimen, however, there was no appearance of any deficiency of size in the left auricle. A failure in the formation of the transverse trunk which becomes the innominate may have been a cause of the persistence of the current in its primitive course; but this could not be ascertained to have been the case. No other peculiarity was remarked.

G. M. HUMPHRY.

In his first lecture, as Professor in the Royal College of Surgeons (reported in the *Lancet*, June 9 and 16, 1866), Mr Hancock enters carefully into the anatomy of the Human Foot, and discusses certain views respecting it, given in my works 'On the Human Skeleton' and 'On the Foot and Hand.'

First: with regard to the influence of the strong plantar fascia and the calcaneo-scaphoid ligament in maintaining the arch of the foot, he seems to think that I attribute too much to the ligaments, and omit to take the muscles into account; and he rightly questions whether the ligaments "possess sufficient elasticity or contractile power to accommodate themselves to the various requirements of the part," and goes on to explain the effect of the muscles in supplementing the ligaments under different circumstances. Had Professor Hancock read a little further he would have found the account that I give very closely agreeing with his own. I speak of the plantar ligament, it is true, as a 'tie-beam' or 'girder,' but as having "an advantage which no tie-beam can ever possess; inasmuch as a quantity of muscular fibres are attached along the hinder part of its upper surface. These instantly respond to any demand that is made upon them, being thrown into contraction directly the foot touches the ground; and the force of their contraction is proportionate to the degree of pressure which is made

upon the foot. Thus they add a living self-regulating power to the passive resistance of the ligament" (*The Human Foot*, p. 25); and I enter at some length on the assistance rendered by the muscles to the ligaments, (pp. 44, 71 et seq.).

Secondly; alluding to the view that in the higher classes of man the leverage afforded by the heel is comparatively short, and the calf-muscle is well developed as a compensation, so establishing a relation between shortness of heel, size of calf and conformation of skull, or intellectual capacity (p. 50), Professor Hancock submits "that the loss of power is not due either to the rapid descent or vertical direction of the heel-bone, but simply to the shortness of the projecting leverage behind the ankle." What I maintain is, that the shortness of the projecting leverage is due to the rapid descent of the heel, which is a necessary attendant upon the high plantar arch of the well-formed European foot, and is associated with a well-developed calf-muscle to compensate for the diminished leverage; and I cannot see that Professor Hancock adduces any good reason for questioning this.

Thirdly; the Professor objects to my describing the astragalus as the 'summit' and 'key-bone' of the plantar arch, because the astragalus is not situated in the centre of the arch, and he considers that from the position which the scaphoid occupies in the foot there can be no doubt that it is the true key-bone of the arch. "In mechanics," he says the "key-stone is that which is inserted, wedge-shaped, into the centre of an arch immediately over its crown or highest central spot from the ground, having an equal extent of arch on either side." This is all very true of an ordinary arch when the highest stone, which is the key-stone, is the centre-stone; but the highest, or key-stone, is not necessarily the central stone; and in the instep, which is not an ordinary arch, the highest bone (the astragalus) is not the centre bone. It is, however, none the less the key-bone. It is the bone upon which the lines or springs of the arch (they are nearly straight lines, not curved as in an ordinary arch) converge: it receives the whole weight and distributes it through the two sides to the springs of the arch. To neither of these requirements does the scaphoid answer. It is not the highest bone; it does not receive the whole weight, and it does not distribute any of the weight in the two directions, but only transmits the share of weight which it receives to the fore limb of the arch. I cannot therefore agree with Professor Hancock, and must adhere to the opinion that the astragalus and not the scaphoid is the key-bone of the instep, the os calcis forming the short and the scaphoid cuneiforms and metatarsals the long limb of the arch.

G. M. H.

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PLATE I

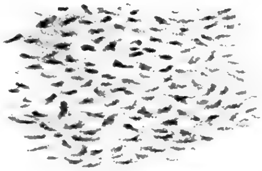


Fig I
× 185

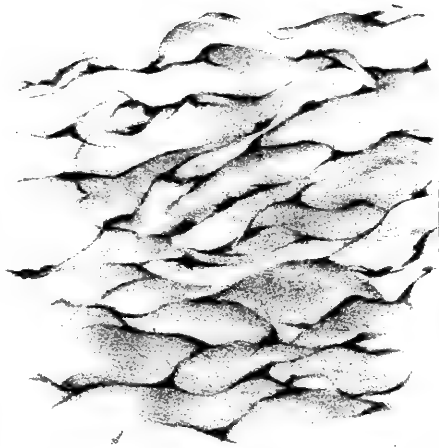


Fig II
× 185

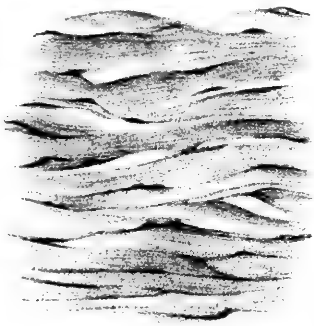


Fig. III. × 185

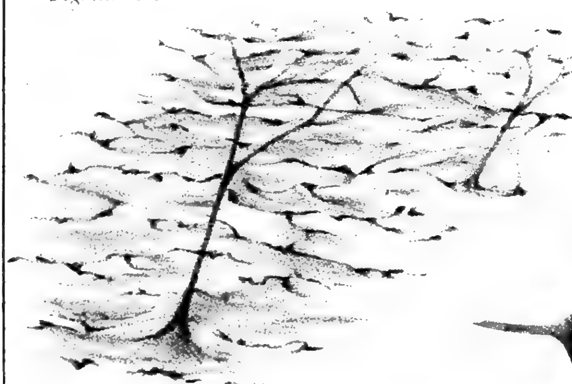


Fig. IV
× 185.

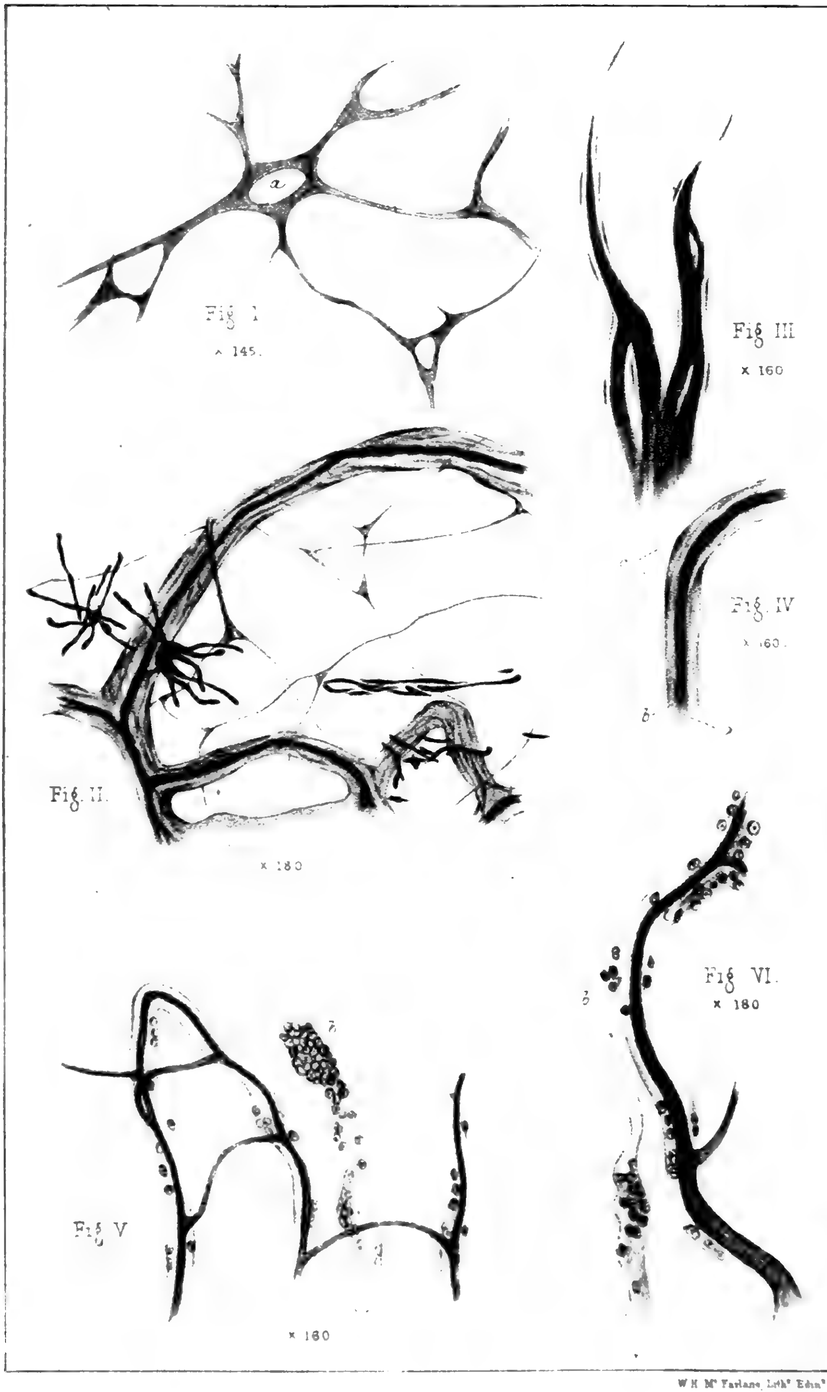
Fig. VI
× 185

Fig V

× 185 diam

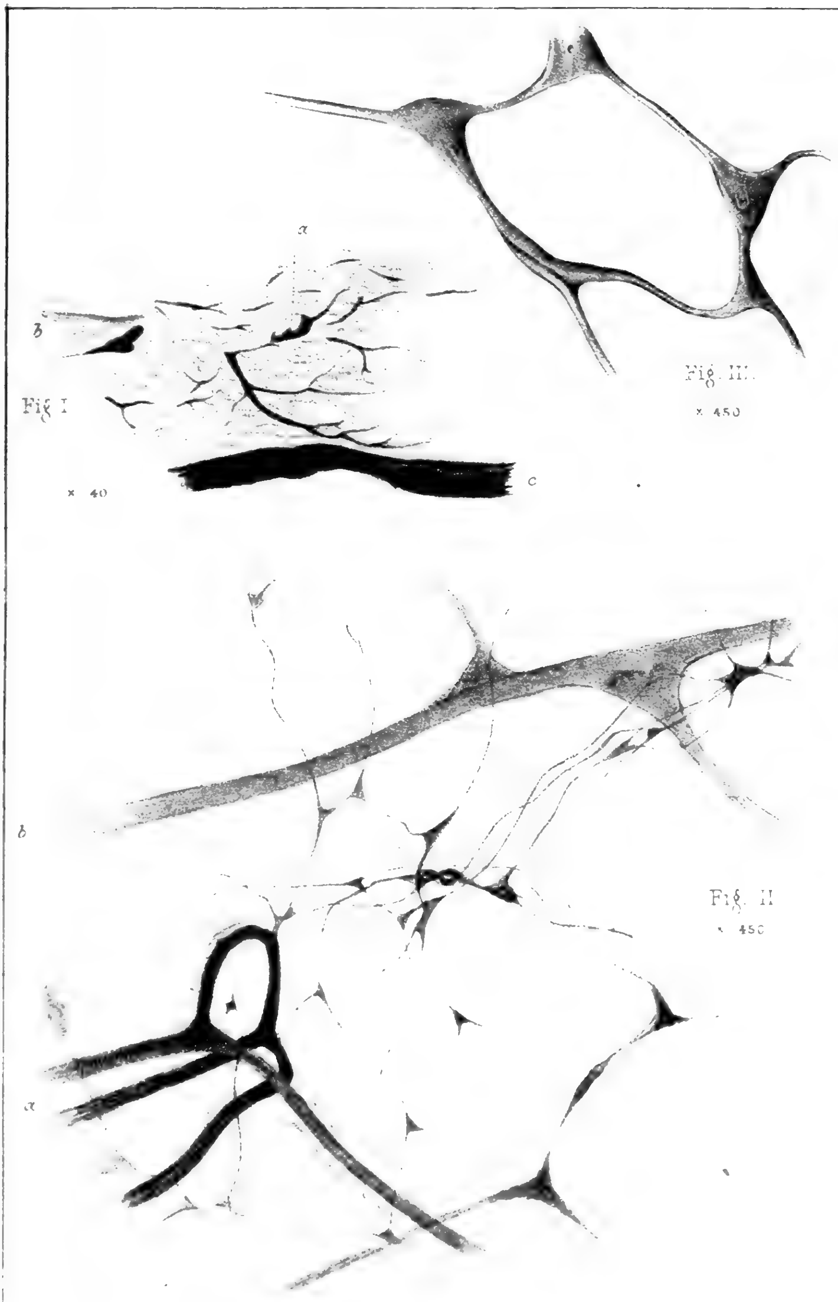
W H Mc Farlane Lithr Edinr

PLATE II.



W H M^c Farlane, Lith^r Edin^r

PLATE III

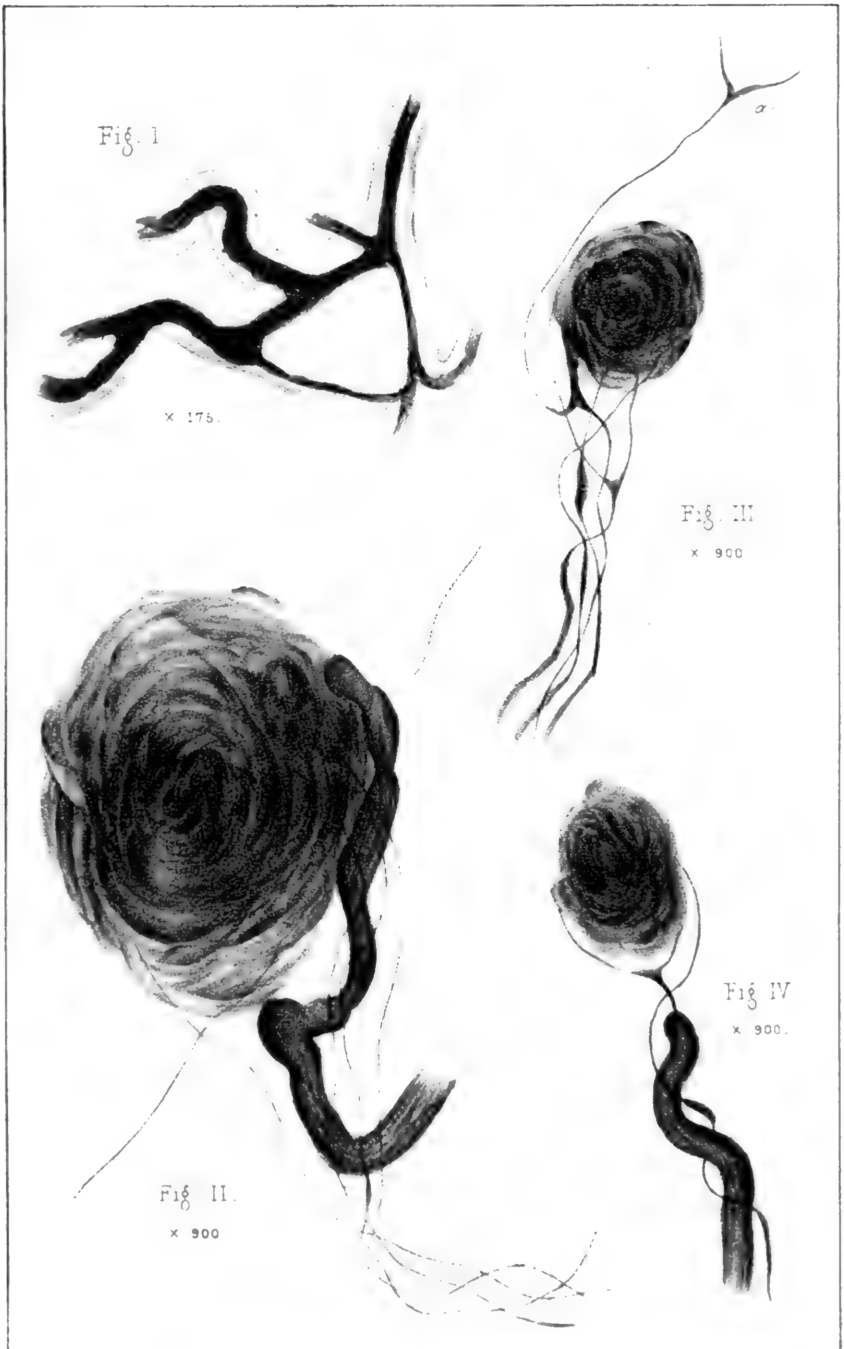


W. H. McFarlane, Lithr Edinr

PLATE IV

W H M' Farlane, Lith^r Edin^r

PLATE V



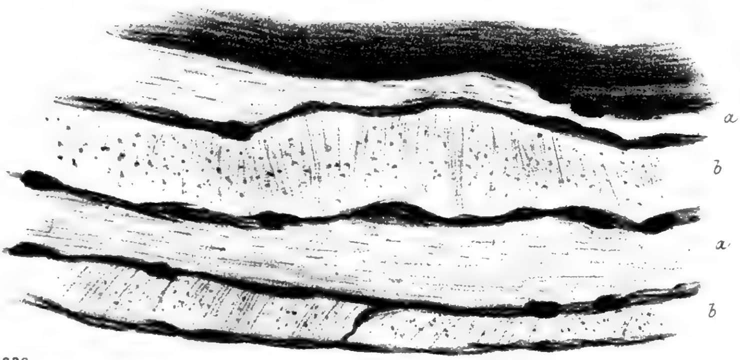
W H Mc Farlane, Lith. Edin.

PLATE VI.

Fig. I

× 175.

Fig. II



× 220.

Fig. III

× 175.

W H M'c Farlane, Lith'r Edin'r

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Two rods of the frog, $\times 1000$. In all the figures in this plate, *a* marks the shaft, *b* the appendage.

Fig. 2. Cones of the frog, $\times 1000$. In this and in the other figures in this plate, *c* marks the cone-head.

Fig. 3. Transformation of the appendages of the cones and rods forming Ritter's "axial fibres." *d*, stout club-like vesicles; *e*, stalked vesicles; *f*, line of membrana limitans externa. From a chromic acid preparation of the frog's retina, $\times 670$.

Fig. 4. Two stalked vesicles displaying stellated vacuoles, $\times 670$. From another part of the same preparation as the preceding figure.

Fig. 5. Rod-shafts of salamander, $\times 670$.

Fig. 6. Cones and rods of anguis fragilis, $\times 670$.

Fig. 7. Central cones of the chameleon, $\times 670$.

Fig. 8. Peripheral cones of chameleon, $\times 670$. *d*, the outer-granule in the inner end of the appendage; *e*, the primitive cone-fibre; *f*, membrana limitans externa.

Fig. 9. Cones from the macula of the chameleon. The shafts are hidden in the choroid. The letters indicate the same parts as in the last figure, $\times 670$.

Fig. 10. Cones and rods of a large green blue-spotted lizard (spe. incerta), $\times 670$.

Fig. 11. Cones of emys or terrapene. *r*, red; *y*, yellow beads, $\times 670$.

Fig. 12. Cones and rods of chelonia mydas. (The left three are the rods). *d*, outer-granule lying in the appendages; *r*, red; *y*, yellow cone-beads.

PLATE II.

Fig. 1. Outer-granules of frog; *a*, circular; *b*, myrtle-leaf granules ensheathed in appendages of the cones and rods; *d*, outer limiting membrane; *e*, connective tissue stratum of the inter-granule layer, $\times 1000$.

Fig. 2. Outer-granules of the salamander; *c*, cone or rod-appendix; *f*, primitive cone or rod-fibre, $\times 1000$.

a, *b*, *d*, *e* mark the same parts as in the preceding figure.

Fig. 3. Three cone or rod appendages with primitive fibres and outer-granules. From the turtle, $\times 1000$. The same letters are used as in the last figure.

Fig. 4. Represents a vertical section of the outer and inner-granule, and part of the granular layer of the turtle.

h, outer-granule layer; *i*, inner-granule layer; *k*, granular layer.

a, circular outer-granules; *d*, outer limiting membrane; *g*, inner-granules; *l*, a compound cone or rod-fibre of the plexus, which contributes to the inter-granule layer; *m*, a Müller's vertically radial connecting-tissue fibre.

Fig. 5. A branched ganglion-cell of the turtle, ×1300.

Fig. 6. Represents a vertical section through the outer layers of the retina of the gecho, ×670.

a, outer-granules lying in *c*, the appendages of the cones; *b*, primitive cone-fibres; *d*, outer limiting membrane; *e*, connective tissue portion of inter-granule layer; *f*, finer oblique cone-fibres; *g*, stouter ditto, formed by the union of the finer fibres; *h*, vertically radial connective tissue-fibres (Müller's); *i*, granular layer.

PLATE III.

Fig. 1. A vertical section radial from the fovea centralis, and parallel to the bundles of the cone-fibre-plexus which forms the principal part of the inter-granule layer in this situation. *a*, oblique radial nervous bundles; *b*, vertically radial connective tissue-fibres crossing the nervous bundles, ×670. From the chameleon.

Fig. 2. A vertical section through the outer layers of the retina of the common snake, near the ora, ×760. *a*, cone-shafts; *b*, appendages containing outer-granules; *c*, membrana limitans externa; *d*, obliquely radial cone-fibres in the inter-granule layer; *e*, connective tissue stratum of the same layer; *f*, distant outer-granules (?) with primitive cone-fibres; *g*, inner-granules.

Fig. 3. Vertical section through the centre of the optic nerve of the boa, ×20. *n*, the nerve; *p*, pecten; *v*, a blood-vessel passing out of the pecten and channelling the hyaloid capsular membrane of the vitreous humours; *r*, retina; *ch*, choroid; *sc*, sclerotic.

Fig. 4. A vertical section through the inner layers of the boa's retina, ×1000. *a*, the granular layer; *b*, arcade-like spaces between Müller's fibres which contain the ganglion-cells, and optic nerve fibres; *c*, Müller's fibres; *d*, membrana limitans interna; *e*, divided blood-vessels in the hyaloid capsule of the vitreous humour.

PLATE IV.

Fig. 1. A vertical section through the inner layers of the gecho's retina, ×670.

a, finer obliquely-radial nervous fibres in the inner-granule layers; *b*, stouter do.; *c*, fibres passing from the inner-granules through *g*, the granular layer, to the ganglionic layer; *d*, vertically radial connective tissue-fibres arising at *f*, from *i*, the membrana limitans interna; *e*, inner-granules; *h*, optic nerve fibres.

Fig. 2. A vertical section tangental to the fovea centralis of the chameleon, ×670.

a, the choroid hiding the cone-shafts; *b*, the cone-appendages; *c*, membrana limitans externa; *d*, outer-granules; *e*, vertically radial connective tissue-fibres arising in *f*, a thin stratum of connective tissue constituting the smaller part of the inter-granule layer, and ending in *c*. These fibres form long spaces in which are seen *g*, the cut ends of the bundles of the nervous plexus which composes the principal part of the inter-granule layer.

Fig. 3. A vertical section through the centre of the chameleon's fovea, ×20. *c*, choroid; *b*, bacillary layer; *o*, outer-granule layer; *i*, inter-granule layer; *i′*, inner-granule layer; *g*, granular layer; *n*, optic nerve and ganglionic layers; *f*, fovea.

Owing to a slight folding of the section the cones appear shorter at the centre of the fovea instead of longest, as they actually are.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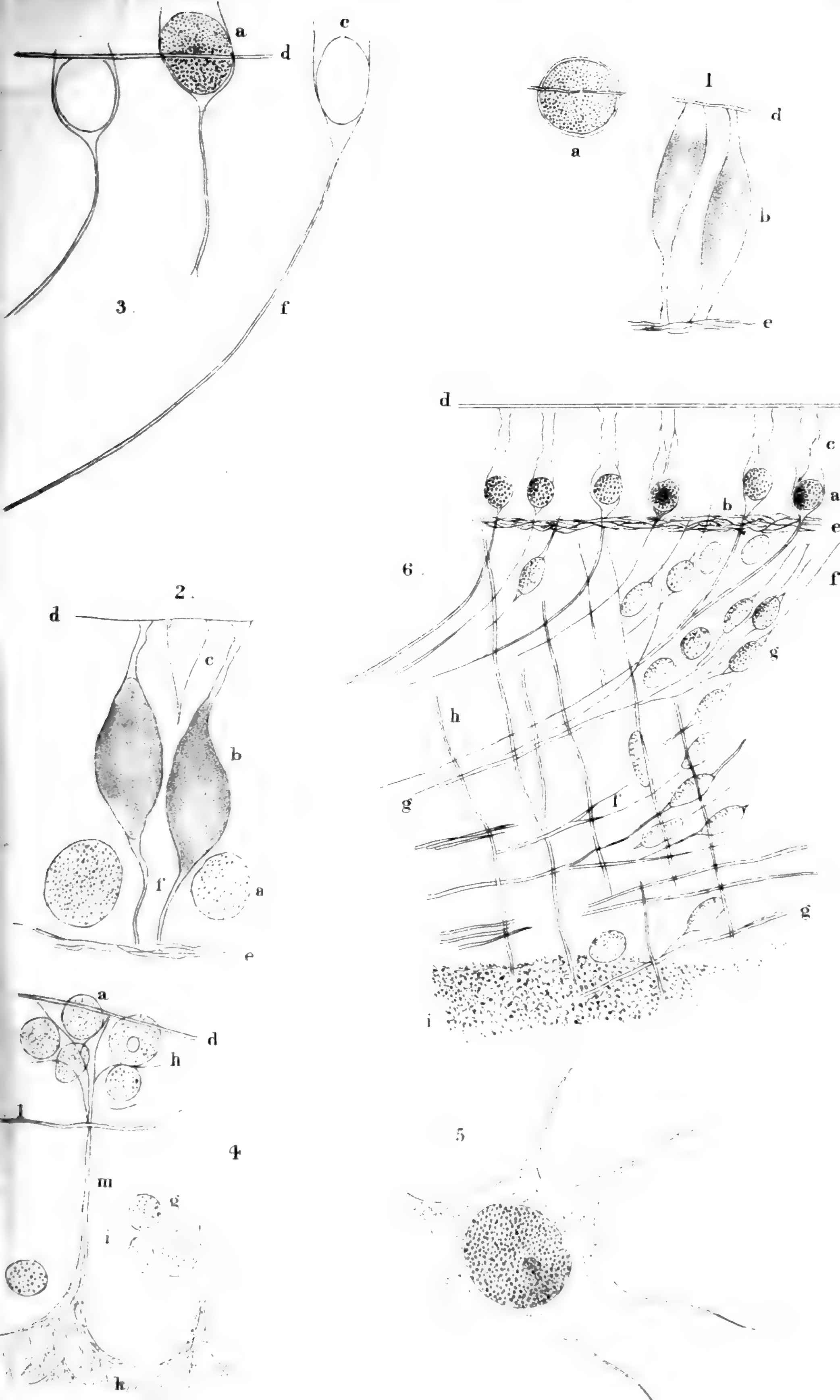

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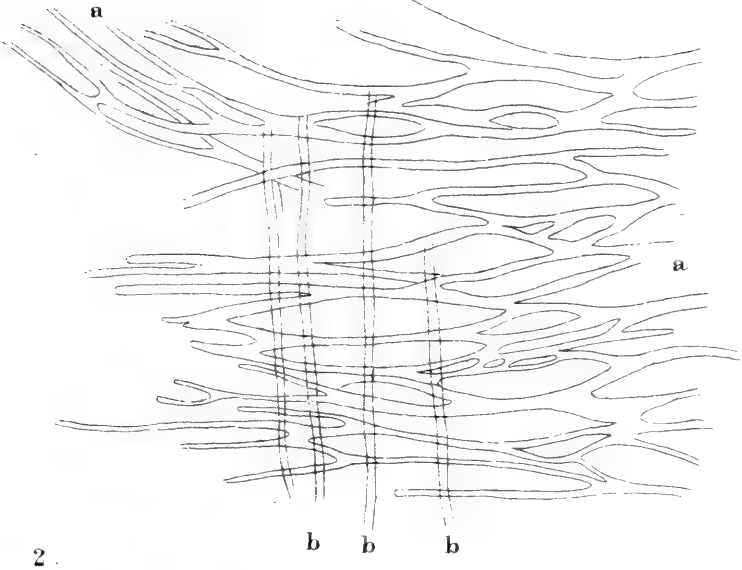

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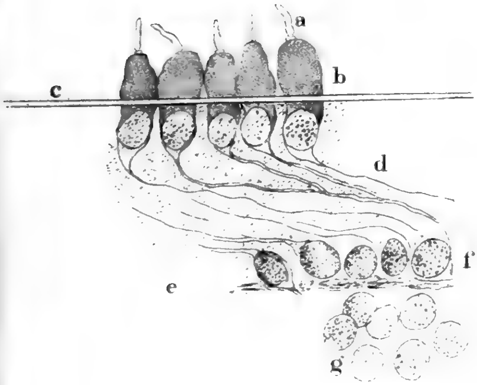

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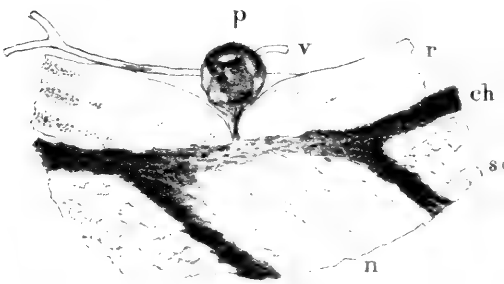

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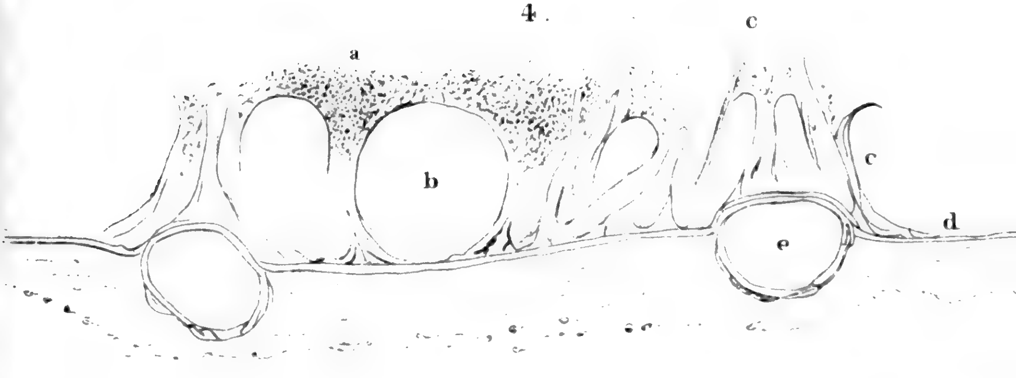

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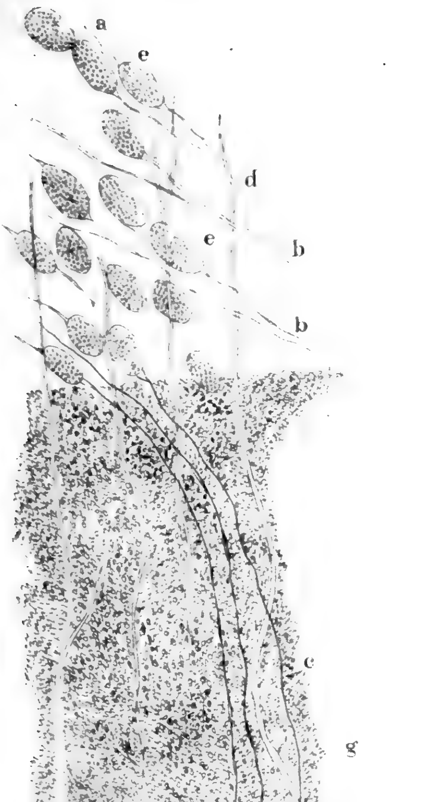

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Journal of Anatomy and Physiology.

ACCOUNT OF THE DISSECTION OF A BUSHWOMAN.

By W. H. FLOWER, F.R.S., F.R.C.S., *Conservator of the Museum of the Royal College of Surgeons of England,* and JAMES MURIE, M.D. *Prosector to the Zoological Society of London.*

OBSERVATIONS upon the comparative anatomy of the different races of Man have hitherto been confined too exclusively to the external characters and to the skeleton. With very few exceptions the arrangement of the muscles, vessels, viscera, and even of the brain and nervous system, constitute at present an unexplored field; and numerous well-marked races of our species are passing away from the face of the earth without the slightest record being left on any one of these points. And yet in discussing questions, daily becoming of greater interest, relating to the unity or plurality of mankind, and the amount of divergence of races, data such as these afford, whether their testimony be negative or positive, whether they tend to show absence or presence of variation from a given standard, cannot be neglected by the conscientious enquirer.

The value of a single instance, such as that about to be recorded, may be considered by itself as insignificant, and yielding little result to compensate for the amount of labour expended upon it; it is, however, only by an accumulation of such instances that the materials for the foundation of a scientific system of ethnology can be formed.

The Bushman or Bosjesman race has, it is true, already received some attention from anatomists. A description of the brain of one of them by M. Gratiolet[1], and, more recently, that of another by Mr Marshall[2], may be placed among the most valuable contributions hitherto made to comparative anthropotomy. The external characters, especially of the reproductive organs, have formed the subject

[1] *Mém. sur les plis cérébraux de l'Homme &c.* Paris, 1854.

[2] *Phil. Trans. Roy. Soc.* 1864. Part III. p. 501.

of memoirs by Cuvier[1], De Blainville[2], and Müller[3]. Observations have also been made upon the peculiarities of the cranium and other parts of the skeleton in a very few individuals of the race.

In or about the year 1853 two children of this race, a girl and a boy, were brought from their native country, by way of Port Natal, to England, and exhibited in London and the provinces. They were supposed at the time of their arrival to be about ten or twelve years old. The boy died a few years afterwards, and was buried in a cemetery in South Wales. The girl lived longer, but ultimately died in London, of pulmonary phthisis, on the 16th of June, 1864, and her body was sent to the Royal College of Surgeons for the purpose of dissection. The general condition of the body, development of the teeth, and ossification of the skeleton, quite corresponded with the age assigned to her.

We were unable to learn many particulars as to her mental condition and character, but she was described as possessing a fair amount of intelligence. She spoke English fluently, and showed an aptitude and fondness for music, playing the piano with facility.

In compiling the following notes our attention was chiefly directed to the more perishable soft structures of the body. The skeleton, which is preserved in the Museum of the College, may form the subject of future examination.

External Characters.

In general outward appearance she bore evidence of being a genuine example of the Bushman race, agreeing in all the essential particulars with the "Hottentot Venus," as described by Cuvier[4]. The differences in detail, for the most part, may be attributed to the younger age of the present individual.

The body on the whole was lightly built, and the limbs slender. There was no emaciation, however; indeed, we were surprised at the amount of subcutaneous fat in some parts; on the front of the thigh, for instance, it measured ·4″ in thickness[5]. The very remarkable accumulation commonly found on the gluteal regions of females of this race, and so often alluded to by travellers, can scarcely be said to be present; at all events, it scarcely approached that described in the "Hottentot Venus." Still the fat of the buttocks was fully $1\frac{1}{4}''$ in thickness, and the skin over it had a remarkably loose, flaccid,

[1] *Mém. Mus. Hist. Nat.* 1817, p. 259.

[2] *Bull. Sci. Soc. Philom.* 1816, p. 183.

[3] *Archiv fur Anat.* 1834, p. 319.

[4] *Loc. cit.* p. 270, &c.

[5] It may be here remarked that the adipose tissue presented in an unusual degree the peculiar bright rich yellow hue which it generally does in the dark-skinned races.

and wrinkled character, as if at some previous time it had been more fully distended.

The total weight of the body was 61 lbs. avoirdupoise.

The height, measured after death, was 4′ 7½″, or four inches less than that of the "Hottentot Venus[1]."

The following dimensions, taken with considerable care when the body was extended on the floor, will give an idea of the proportions. The first series are taken from a line drawn transversely across the vertex of the cranium, the line of measurement being always parallel to the axis of the body.

	inches
From the vertex to the chin	8·0
.... top of shoulder	9·0
.... upper part of sternum	10·5
.... tip of ensiform cartilage	16·3
.... umbilicus	22·3
.... upper edge of the crest of ilium	23·0
.... perinæum	30·0
.... tip of middle finger, the arm being placed by the side	32·0
.... lower edge of the patella	41·3
.... sole of the foot	55·5
Transverse breadth of the head	5·2
.... shoulders	12·0
.... thorax at axilla	8·7
.... thorax at lower part	8·4
.... pelvis at crest of ilium	8·6
.... pelvis at great trochanters	11·0
Length of humerus[2]	10·1
.... radius	7·3
.... ulna	7·9
.... femur	14·7
.... tibia	11·7
.... spine from upper border of atlas to tip of coccyx	23·0
.... spine to the last lumbar vertebra (Carus' module)	18·5
Circumference of the chest at the lower margin of the sixth rib	26·6
Span of the arms when extended	53·2

The hands and feet were small and delicately formed. The following dimensions were taken from the right hand in parallel lines

[1] This according to Cuvier was 4′ 6″ 7‴, French measurement, or rather more than 4′ 11⅓″ English.

[2] The measurements of the limb-bones were corrected after the skeleton had been macerated.

from the level of the radio-carpal articulation to the extremities of the fingers.

		inches
Length from wrist-joint to end of	pollex	4·0
	index	5·4
	medius	5·7
	annularis	5·5
	minimus	4·7
	to the root of middle finger	3·3

The breadth of the palm at the bases of the fingers was 2·5″. The end of the thumb reached to within a quarter of an inch of the end of the first phalanx of the index finger. The nails were well formed, narrow, with straight parallel sides and a moderate amount of curvature.

The feet had suffered somewhat from the practice of wearing shoes of the ordinary European shape, by which the ends of the toes are pressed together and towards the middle line of the foot. Both feet agreed precisely in their dimensions, which were as follows:

		inches
Length from the heel to the end of the	hallux	7·7
	second toe	7·55
	third toe	7·35
	fourth toe	7·0
	fifth toe	6·6
Breadth of the foot at the metatarso-phalangeal articulation		3·0

The second and third toes were distinctly more syndactylous than any of the others. The distance of the bottoms of the clefts between the toes from a line drawn across the end of the second toe at right angles with the axis of the foot, measured:

	inches
First interspace or cleft	1·3
Second	1·1
Third	1·4
Fourth	1·6

A comparison of the dimensions with those of a standard European type will give the following results.

Having projected a diminished outline of the entire body on paper, we first compared it with the beautiful female figure given in G. V. Carus' "*Proportionslehre,*" which appears to have been drawn with great care and accuracy. In order the more readily to illustrate the comparison, we have enlarged the principal measurements of that figure to a scale corresponding with that of the Bushwoman, *i. e.* made the height the same, and placed them in contiguous columns:

	Bushwoman	Carus' figure
From vertex to chin	8·0	7·45
.... top of shoulder	9·0	10·3
.... end of hand	32·0	36·5
From top of shoulder to end of hand	23·0	26·2
From vertex to umbilicus	22·3	22·8
.... perinæum	30·0	30·6
Breadth at shoulders	12·0	12·8
.... thorax	8·7	8·9
.... crest of ilium	8·6	10·3
.... between the great trochanters ...	11·0	11·8

From these data it is seen that in the Bushwoman the head is slightly longer, the shoulders are placed much higher, the arms are very markedly shorter (three inches), the legs slightly longer (half-an-inch), the umbilicus placed somewhat higher, the shoulders narrower, but the thorax is nearly equal in breadth, while the pelvis is considerably narrower, this disproportion of pelvic breadth, however, being much less marked opposite the trochanters. The principal peculiarity then in the Bushwoman appears to be the shortness of the upper extremities, which is also well expressed in the distance from finger-tip to finger-tip of the outstretched arms; this distance being fully two inches less than the total height of the individual instead of equal to it, as is commonly the case in the European.

For the purpose of examining more closely the relative proportions of the different segments of the body, we have placed the measurements (reduced to a scale, the height being as 100) in a table, with similarly reduced measurements taken from Professor Humphry's work on the Skeleton[1]. The upper row of the table contains an average series of proportions derived from 25 European skeletons, the second row the average from 25 Negroes, the next is taken from three Bushmen, and the fourth (for a purpose presently to be mentioned) from a number of European children of from four to six years of age, while the fifth and last row is from the subject of the present communication.

	Height.	Spine.	Humerus.	Radius.	Hand.	Femur.	Tibia.	Foot.
European	100	34·15	19·54	14·15	11·23	27·51	22·15	16·03
Negro	100	31·13	19·52	15·16	12·42	27·40	23·23	17·90
Bushman	100	31·48	20·0	15·37	11·11	27·78	23·83	13·78
European children 4 to 6 years old	100	33·71	18·85	13·71	11·71	26·00	20·28	14·57
Bushwoman	100	33·33	18·20	13·15	10·27	26·49	21·08	13·87

[1] *The Human Skeleton.* Cambridge, 1858, p. 108, Tab. IV.

Her proportions, therefore, differ widely from the average standard of the white and black races, in so far as these are represented in the accompanying table, and even from the three recorded examples of her own race. Some difference must certainly be allowed for sex, the above quoted table being compiled apparently from subjects of both sexes indiscriminately, with probably a preponderance of males. The shortness of the upper limbs appear as a marked feature, and is distributed through each of its segments in about equal proportions; whereas in the other Bushmen and Negroes the upper limb, more especially the radial segment, is considerably longer than in the European. The lower limbs also appear in this table proportionally shorter, which was not the case in our previous comparison with the standard given by Carus; but this may be due partly to sex. The hands and feet present the remarkably diminutive condition characteristic of the Bushman race, contrasting strongly in this respect with those of the Negro. Perhaps the most interesting general feature is, that there is no indication of that pithecoid elongation of the distal as compared with the proximal segments of the limbs seen in the Negro, but rather the reverse.

On comparing the proportions of the segments of the limbs with the mean of those of numerous individuals at various ages, as given by Humphry[1], we are struck with the remarkable agreement between them and those of the European child between four and six years old. It would indeed appear as if the proportions of a child of that age had been permanently retained.

The details of the hands and feet present nothing very different from the ordinary European type. Race differences might naturally be looked for in the comparative length of the toes or the depth to which they are divided, as so great a difference in this respect is found between man and the anthropoid apes, and also among the genera of the latter. But we could find no external character in the Bushwoman's foot that would differentiate it from that of the European. The great toe is rather the longest, but such is the case in many individuals of the higher races, although according to the canons of ancient art it should be shorter.

It is not a little remarkable that a hallux shorter than the second toe should have come to be considered as necessary to the perfect beauty of the human foot. As the hallux is so frequently suppressed, or rudimentary, in the lower mammals, and as its comparative shortness is characteristic of all apes, while in man alone it approaches or surpasses the second toe in length, we might naturally look to an elongated great toe as a mark of superiority of type, and expect to find it most developed in the higher races of mankind.

[1] *Loc. cit.* p. 111, Tab. VIII.

The prevailing colour of the skin may be described as a light yellowish brown, tolerably uniform in tint on all parts of the body, but the abdomen and thighs were a shade darker than the face and neck. The palms of the hands and the soles of the feet were almost white.

The face was remarkable for its great general breadth and flatness, and presented that resemblance to the Mongolian type of countenance previously noticed by several authors. The outline was peculiar and characteristic, being very broad in the malar region, contracting above at the forehead, but tapering more markedly and suddenly below to the narrow chin. The supra-orbital ridges were moderately prominent, and there was very little depression at the root of the nose. The forehead was moderately developed. One of the most striking characters of the features was the great space between the eyes, which measured 1·8″. A prominent fold of skin curving round from above the upper lid to the side of the nose completely covered the inner canthus of the eye. The apertures of the eyelids were placed horizontally, and measured ·95″ in length. The irides were dark brown, and the conjunctiva had an olive-brown tinge. The nose was nearly straight in profile, broad and very much depressed, 1·5″ across the *alæ*, and but ·5″ from the root of the septum to the tip. The grooves separating the *alæ nasi* from the cheek were little marked. Nostrils patulous, of a regular oval form, ·5″ in length and ·3″ in breadth, opening downwards and slightly forwards. Septum narium short and broad. Aperture of the mouth 1·7″ in width; lips broad and everted, more especially the upper one. Chin flat, narrow, and rather angular. The pinna of the ear 2·1″ in vertical diameter, with the lobule very slightly developed.

The hair on the scalp was black, and arranged in numerous separate tufts, each composed of a bunch of fine spirally-curled hair, much interwoven. The length of the tufts on the top of the head was from 1″ to 1½″, becoming shorter and smaller at the edges of the scalp. Several of the individual hairs when pulled straight were found to measure 6″ in length. On a careful examination of the scalp it was ascertained that the hair did not grow in distinct patches with bare intervals, as has been asserted, but the roots were evenly scattered, the aggregation into tufts being due to a peculiar tendency in the hairs themselves.

The eyebrows were very scanty. The eyelashes consisted of short fine hairs, ·2″ long on the upper and scarcely perceptible on the lower lid. In the axillæ were a very few, fine, curled hairs, not exceeding ½″ in length. On the pubes and labia majora a few small scattered tufts of crisply-curled fine black hair were present; when pulled out straight they measured 2″ long.

The mammæ were situated exactly over the fourth and fifth ribs, and were 5″ apart at the inner edges of their bases. They were soft, flaccid, and subpendulous; 3″ in diameter at the base, and about the same from base to apex. Nipple very slightly prominent, of a blackish brown hue and ½″ in diameter. An areola, darker than the neighbouring skin, extended around for 1½″ from the centre of the nipple.

The remaining external characters will be described under the head of *Generative Organs.*

Muscular System.

In describing the muscles it has been considered necessary to refer here only to those presenting some special points of interest. At the same time it is right to state that, with the exception of those of the eye, pharynx, and deep layers of the vertebral region, every individual muscle of both sides of the body came under our scalpel. In the case of those not particularly mentioned, it may be presumed that no departure was observed from the typical arrangement in the white races.

Muscles of the face.—Although the facial muscles exhibited nothing very unusual, the interest attaching to whatever concerns the anatomy of expression and of the physiognomy may render them worthy of being mentioned.

Orbicularis palpebrarum.—This was rather delicate and pale, as were the remainder of the muscles of the face. It was, as usual, elliptical in contour, the most marked curve being to the outer angle and lower part of the orbit.

The *pyramidalis nasi* was represented by fibres reaching downwards as far as the lower part of the nasal bones; its upper portion was about ¾″ in breadth.

Compressor naris.—Distinct though scanty in fibres. Its greatest breadth was ½″; the upper edge being parallel with the free border of the nasal bones.

The *levator labii superioris alæque nasi* did not appear to be double; at least, we could not easily separate it into two slips. The fibres that existed descended to the ala of the nose, the outer and lower border of them intermingling with the following.

Levator labii superioris proprius.—Fully ½″ broad in its origin at the lower and inner border of the orbit. Its fibres as they passed downwards increased in breadth by their union with those of the levator labii superioris alæque nasi and the zygomaticus minor, these three muscles having a common insertion into the orbicularis oris.

The *zygomaticus minor* was partly fused with the orbicularis

palpebrarum and zygomaticus major above; immediately below this was well defined and with a considerable body of fibres. Its insertion was common with the preceding muscle.

Zygomaticus major.—Well developed; it united with the levator anguli oris at its insertion.

The *depressor anguli oris* and the *depressor labii inferioris* were both unusually well developed, the latter forming a distinct prominence, and mainly causing that protuberant under lip so characteristic of the Negro tribe. Their attachments were as usual.

Ear muscles.—The *retrahens aurem* was moderately developed. It arose by two slips from the base and middle of the mastoid process, and had the usual insertion. The *attollens* and *attrahens aurem* were injured in removing the calvarium.

Muscles of the front of the neck and of the abdomen. Sterno-mastoid.—The sternal and clavicular attachments of this muscle were distinct. The former arose by a long slender tendon; the latter by muscular fibres from the inner end of the clavicle of a breadth of 1·7″.

Omo-hyoid.—This muscle presented the peculiarity on both sides of having no origin from the scapula. Its inferior extremity spread out to form a somewhat widened attachment to the clavicle about an inch from the outer end and behind the trapezius. The muscular fibres in ascending the neck had no appreciable tendinous intersection, but were enclosed and bound down by fascia, so as to produce the bending or angular change of direction, which however was less marked than usual. Above the muscle was adherent at its inner edge to the sterno-hyoid and ended in a tendinous fascia, ·3″ in length, over the hyoid bone and rather to its outer side.

The attachment of the omo-hyoid muscle to the clavicle does not seem to be peculiar to the Bushman, nor indeed very rare in Europeans, as Hallett[1] states that it was found by himself in five subjects out of a hundred, and he gives three per cent as the general average of its occurrence. Mr Turner[2] agrees with Hallett as to the frequency with which it is observed, and further states that in 17 cases in which he has seen this anomalous posterior attachment, in 8 it occurred on both sides, in 4 only on the right, and 5 only on the left side.

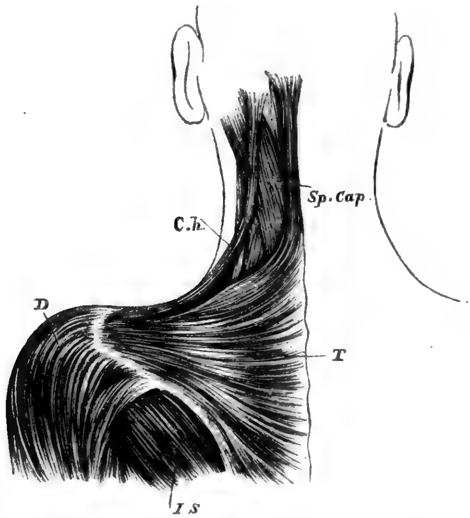
Cephalo-humeral, or Cleido-occipital.—Among the more striking variations in the muscular system may be mentioned the presence of a distinct cephalo-humeral. This existed most markedly on the left side, as a long narrow slip of fibres which arose from the occiput

[1] *Edinb. Med. and Surg. Journal,* 1848 and 1849, pp. 3, 4.

[2] Ibid. 1861, p. 982.

half an inch to the outer side of the trapezius, and proceeding down the neck, at nearly an equal distance and almost parallel with the outer border of that muscle, for a distance of about a couple of inches, then diverged outwards, and crossed the posterior inferior triangle of the neck, its fibres being inserted into the outer and anterior aspect of the clavicle, an inch from the acromio-clavicular articulation. (fig. 1. *C. h.*) At this point its fibres were in close relation with those of the trapezius, but yet clearly separable. At its origin it was closely adherent to the splenius capitis, over which it lay.

Fig. 1.



Some of the older anatomists mention an occasional slip derived from the trapezius, and Quain[1] figures such an example.

Hallett[2] refers to three instances which came under his own observation, but Mr Wood[3] was, so far as we are aware, the first clearly to indicate and figure this slip, as an occasional representative in man of a muscle, which in some of the Quadrumana and lower mammals is of tolerably constant occurrence. In these as in man it is sometimes partly fused either with sterno-cleido-mastoid or the trapezius, but as often (in the Carnivora for example) forms the distinct and very peculiar cephalo-humeral muscle of comparative anatomists.

While admitting that the term "cleido-occipital" given to it by Mr Wood is more expressive of this muscle's attachments in man, we

[1] Plates of the Arteries, Pl. 25.

[2] *Loc. cit.* Jan. 1848, p. 7, and July 1848, p. 5.

[3] "Varieties in Human Myology," *Proc. Roy. Soc.* 1866, p. 230, fig. 7*a*.

prefer to retain the term "cephalo-humeral" on the grounds of its having the priority, of its indicating clearly the attachments of the muscle when completely developed, and moreover as leading to a keener appreciation of its interest as an abnormal muscle in the human subject.

The *rectus abdominis* muscle had three well-marked transverse tendinous bands.

The *psoas parvus* was absent on the left side. The inconstancy of this muscle is well known to all anatomists. Hallett has shown, in opposition to older authorities, that sex has no influence on its existence, and that it is more frequently found on the right than the left side.

Muscles of the back of neck and trunk.—There was no trace of any fibres continued from the normal *latissimus dorsi* to represent the *dorso-epitrochlear* of the lower mammalia.

The *levator anguli scapulæ* arose from the posterior tubercles of the first, second and fourth cervical vertebræ, and had the usual insertion, but there was also an additional slip which passed downwards to the middle of the serratus magnus. This latter may be an indication of the *levator claviculæ* noticed by M^cWhinnie, and well known to comparative anatomists, though the name was first recognised in human myology by Wood[1].

The *splenius colli* was inserted by a double tendon into the transverse processes of the two upper cervical vertebræ, the lower tendon being the larger.

The *cervicalis ascendens* was distinctly separate from the sacro-lumbalis. It arose by delicate tendons from the posterior angles of the first, second, third and fourth ribs, which joined in a muscular belly sending off similar slips to the transverse processes of the sixth and seventh cervical vertebræ.

A long thin muscle occupied the place of the *transversalis cervicis*. It arose by a strong tendon from the tip of the transverse process of the tenth dorsal vertebra, and ascending in a straight line became muscular opposite the sixth rib, where it was as much as four-tenths of an inch in breadth, but tapered towards the second rib, at which place it formed a tendon which terminated by insertion into the transverse process of the fifth cervical vertebra.

The *trachelo-mastoid* was divided into two portions. The one, a flat fleshy muscle, arose by delicate tendons from the posterior part of the transverse processes of the first, second, third and fourth dorsal vertebræ, and was inserted into the articulating processes of the second to the seventh cervical vertebræ. The other, or mastoid portion, thin,

[1] *Loc. cit.* 1864, p. 300; 1865, p. fig. 1 *a*; 1866, p. 230.

delicate, and membranous, sprung by delicate tendons from the transverse processes of the fourth and first dorsal, and from the seventh, sixth, and fifth cervical vertebræ, as also by membranous attachment from the first and second cervical vertebræ. It was inserted into the whole length of posterior border of the mastoid process.

As frequently happens, the *complexus* and *biventer cervicis* were partially united. They arose by muscular slips from the seventh to the second dorsal vertebræ, and from the transverse processes of the seventh to the second cervical vertebræ, ascending by two heads; the one (1″ broad) was inserted into the superior curved line of the occiput, the other, smaller in size, joined the corresponding muscle of the opposite side of the neck, both being inserted into the posterior tubercle of the occiput.

The occipital group of muscles were all strongly developed. The *rectus capitis posticus major* was partially divided into two, the outer portion being the larger. The *obliquus capitis superior* was also in two layers, the one inserted into the outer end of the oblique line of the occiput, the other into the roughened line beneath this.

Among the anatomists of last century Albinus[1] and Sandifort[2] both mention an additional slip as occasionally found with the rectus capitis posticus major, and Douglas[3] says that it is "as it were divided into two thin portions;" in the dog, where it is double, he names the second portion *rectus medius*.

Muscles of the upper limb.—As topographically connected with the muscles of shoulder and arm, we may mention that the transverse ligament of the scapula was unusually long. It extended from the angle of the coracoid process and the superior border of the scapula to within ·8″ of the posterior angle. Between it and the upper border of the scapula was a large oval opening ·7″ long and ·3″ wide, through which both the supra-scapular nerve and *artery* passed. There was no proper notch to the upper border of the scapula.

Triceps.—The two usual humeral origins were fused into a single head, which reached as high as the insertion of the teres minor. Scapular origin normal.

The *coraco-brachialis* arose in common with the short head of the biceps and was inserted into the humerus for a length of 2″, the lower end being 6·5″ from the head of the bone. As not unfrequently happens[4], a small muscular slip was given off from the outer side and inserted separately into the front of the humerus ·4″ external to the upper margin of the main insertion. The musculo-cutaneous nerve passed between these divisions of the muscle.

[1] *Hist. Musculorum* (1734), p. 385.
[2] *Exercit. Acad.* (1783), p. 92.
[3] *Myograp. comp.* (1763), p. 95.
[4] Albinus, Meckel, Quain, &c.

The tendon of the *extensor minimi digiti* in the right hand divided above the annular ligament into two distinct tendons, which passed under the ligament in separate grooves, and proceeding over the metacarpo-phalangeal articulation were re-united, and joining with the tendon of the extensor communis digitorum formed the tendinous expansion upon the dorsum of the fifth digit. In the left hand the tendon was also split, but the two divisions passed through the same groove.

This muscle in man is subject to various irregularities; many examples of which are recorded by Hallett[1] and Wood[2].

The *extensor ossis metacarpi pollicis* arose from the middle third of the radius, the interosseous membrane, and from the border of the ulna below the supinator brevis. Two distinct tendons were given off from different parts of the muscle. One, slightly larger than the other, arising from the more superficial part, was inserted into the radial border of the metacarpal bone. The second and longer tendon commenced in the deep portion of the muscular belly, proceeded under cover of and slightly to the radial side of the first-mentioned tendon, and with it crossed the tendons of the extensor carpi radialis longior and brevior, and the insertion of the supinator longus, to the radial border of the trapezium, into which it was attached.

This mode of insertion is that which is commonly met with in the Quadrumana. Recent researches have also shown that it is frequently met with in the white races of man, and that a partial insertion into the trapezium is the rule rather than the exception[3].

The *extensor primi internodii pollicis* was normal in its development and attachments.

The *extensor secundi internodii pollicis* divided into two tendons, which passed together under the annular ligament, but again united opposite the metacarpo-phalangeal articulation of the thumb into a single tendon, inserted into the base of the ungual phalanx. A small muscle, corresponding to the *m. interosseus volaris primus* of Henle[4], was present.

The *adductor pollicis* arose by a series of fleshy digitations from the heads of the third and fourth metacarpal bones, the anterior ligaments of the joints, and by a tendinous band from the head of the fifth metacarpal bone, but it had no origin from the palmar surface of the third metacarpal bone except at its head.

The *lumbricales* of the hand had their usual origins and inser-

[1] *Loc. cit.* 1848, p. 16, and 1849, p. 13.

[2] *Loc. cit.* 1864, p. 301; 1865, p. 9, and 1866, p. 237, fig. 5, *b, c*.

[3] See Huxley's "Lectures." *Medical Times and Gazette*, 1864, Vol. I. p. 177.

[4] *Anatomie des Menschen*, 1858. Vol. I. Part III. p. 228.

tions, except that the third divided into two near the distal extremity, and ended in tendons inserted into the contiguous sides of the extensor sheaths of the third and fourth digits.

Such an arrangement seems to be of not unfrequent occurrence[1]; Mr Wood[2] specially notes three cases which came under his observation.

Between the *adductor* and *flexor brevis minimi digiti manus*, but deeper and lying upon the opponens, was a small but clearly separable muscular slip, half the size of the flexor brevis. It had a separate origin from the process of the unciform bone, and a separate insertion into the base of the first phalanx, nearer the joint and rather anterior to the flexor brevis.

This evidently corresponds to the accessory portion of McWhinnie, and to a somewhat similar modification described by Hallett and by Wood[3].

The *opponens minimi digiti* was largely developed and divided into two portions, one of which arose from the annular ligament, and was inserted into the inner part of the head of the metacarpal bone; the other arose from the unciform bone, and was inserted into the whole of the ulnar border of the metacarpal bone.

Muscles of the lower limb.—The *gluteus maximus* had nearly the usual origin and insertion, but the muscular fibres were thin, flabby, and very badly developed, thus showing that the protuberance of the buttocks, so peculiar to the Bushman race, is not the result of muscular development, but totally dependent on the accumulation of fat. On removing the fascia from the superior border of the gluteus maximus a considerable portion of the gluteus medius was exposed.

Close to its insertion the tendon of the *tibialis anticus* could be divided into two, nevertheless these were closely bound together by areolar tissue. The posterior division of the tendon was seen to be nearly twice the diameter of the anterior. The double insertion of this tendon, so marked in all the Quadrumana, is also generally found in the white races of man, although not described in all text-books of anatomy.

The *peroneus tertius* arose from the fibula below and in conjunction with the extensor longus digitorum. Its tendon was small, but became wide and flat at its insertion, which on the right side was into the upper surface of the proximal end of the fourth metatarsal bone, a slip also going to the inner edge of the fifth metatarsal, as observed in two instances by Wood[4]. Through these divisions of the tendon that of the extensor brevis for the fourth digit passed.

[1] Meckel, *Op. cit.* p. 279.
[2] *Loc. cit.* 1865, p. 389, and 1866, p. 235.
[3] *Loc. cit.* 1864, p. 302; 1866, p. 239.
[4] *Op. cit.* 1866, p. 239.

On the left side the entire insertion was into the upper and tibial border of the fifth metatarsal.

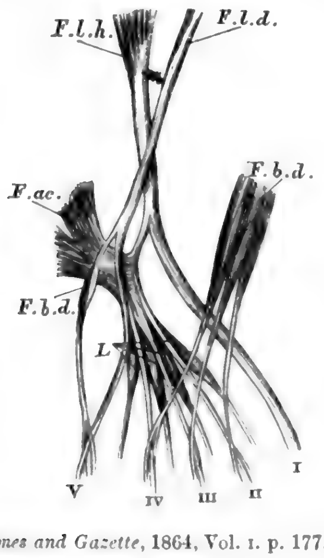
The *extensor brevis digitorum* had its usual origin from the os calcis. It divided into three elongated pointed bellies, the innermost of which was as large as the other two taken together. The first ended in a tendon inserted into the base of the proximal phalanx of the hallux. The middle part ended in a short, broad tendon, which joined the tendon of the extensor longus of the fourth digit near the head of the metatarsal. The tendon of the third and smallest division ended by joining the extensor sheath of the same digit, passing between the points of insertion of the peroneus tertius.

Thus the extensor brevis digitorum had its tendons distributed to the first and fourth digits alone, a very unusual arrangement.

The tendon of the *flexor longus digitorum pedis* divided as usual in the sole of the foot into four tendons, which being joined by the smaller slip of the flexor longus hallucis supplied the four outer toes, the tendon for the fifth toe being entirely derived from this muscle (see woodcut, No. 2, *F. l. d.* v).

The *flexor longus hallucis* divided into two branches, of which the inner was more than twice the size of the outer. The former went to the hallux, while the latter, after being joined by the flexor accessorius, divided into three slips, which united with the tendons of the flexor longus digitorum to form the perforating tendons of the second, third, and fourth digits respectively. This arrangement of the flexor tendons, so different from that commonly described, is now well known to be very frequently met with in the human foot[1].

Fig. 2.



[1] See Huxley, *Med. Times and Gazette*, 1864, Vol. I. p. 177, and Turner, *Trans. Roy. Soc. Edin.* 1865, Vol. XXIV. p. 181.

The *flexor brevis digitorum pedis* presented rather anomalous characters, and might be said to form two distinct muscles. The main portion, as usual, had origin from the inner tuberosity of the os calcis, and the plantar fascia, but divided into only three tendons, which went respectively to the second, third, and fourth digits (fig. 2, *F. b. d.*). The second smaller portion had its origin from the plantar surface of the tendon of the flexor longus digitorum (fig. 2, *F. b. d.*), at the hinder part of the sole of the foot, half-an-inch above the insertion of the flexor accessorius. It was a small vermiform muscle, tendinous at its commencement, and terminating in a tendon going to the fifth or outer digit. In the left foot this tendon was perforated, allowing the long flexor tendon to pass between its divisions, but in the right foot we found that it passed without dividing to the outer side of the deep tendon, and finally was inserted into the plantar surface of the middle phalanx of the toe.

This condition of the flexor brevis is interesting from the well-known fact that in the chimpanzee, and all inferior Primates, a considerable portion of this muscle always arises from the long flexor tendon, while in man alone the whole of it commonly takes origin from the os calcis. An arrangement precisely similar to that here figured has, however, been met with in several instances among Europeans, and occurs among the anomalies recently described by Wood.

The *flexor accessorius* was well developed, and, as usual, arose posteriorly by two heads. Its insertion was into the tendon of the flexor longus digitorum and into the outer division of the tendon of the flexor longus hallucis, but it had no connection with the division of the tendon of this muscle which went to the hallux, (fig. 2. *F. ac*). There was no *abductor ossis metatarsi quinti*, but a strong tendinous band stretched from the plantar surface of the os calcis close to the origin of the abductor minimi digiti to the head of the fifth metatarsal bone.

The muscle described by Henle[1] and Wood[2] as the *opponens digiti quinti* did not exist on either foot.

The relation of the arrangements of the muscular system of Man to that of the inferior Primates was first clearly defined by Professor Huxley, in the Hunterian Lectures delivered at the Royal College of Surgeons in 1864, of which unfortunately only a brief abstract has hitherto been published[3]. On referring to the absolutely differentiating characters there laid down, we find that in no case does our subject pass over the boundary line. We also find that in no one of the numerous variations does the approach to Simian characteristics

[1] *Op. cit.* Vol. I. Part III. p. 301. [2] *Loc. cit.* 1864, p. 303.

[3] *Medical Times and Gazette*, 1864.

actually exceed that which has occasionally been met with in the white races of Man. It is however interesting to observe, that in the very significant arrangement of the flexor tendons of the foot, the tendon of the flexor hallucis giving a branch to the fourth, as well as the second and third toes, and part of the flexor brevis arising from the tendon of the long flexor, on both feet alike, the deviation from the specially human condition of these parts is as fully marked as in any case hitherto recorded. Whether this is in any way characteristic of the inferior races of the human species, or a mere coincidence, remains to be determined by future observers.

ARTERIAL SYSTEM.

The vessels were injected and dissected in tolerable detail, but a full description of their distribution would be superfluous, as the variations from the normal standard were not greater than ordinarily met with in Europeans, and offered few points of special interest.

The arch of the aorta, as usual, gave off three great trunks, the arteria innominata being 1·8″ long. The three vessels, although quite distinct, arose so close together that their outer walls were in absolute contact with each other. On the right side the subclavian pursued its common course between the scaleni muscles; the internal mammary being given off ·6″ from its commencement, the superior intercostal close to the outer side of this, and the thyroid axis, dividing as usual into four, to the upper side of these two branches. The vertebral artery sprung from the subclavian immediately behind the thyroid axis, and the profunda cervicis ·1″ external to it.

On the left side the subclavian ascended 1·5″ and gave off anteriorly the internal mammary. Immediately above and ·1″ externally the thyroid axis was given off, parallel with and behind this the vertebral artery, while the superior intercostal branch sprung still more posteriorly. The thyroid axis at a distance of ·2″ from its parent trunk gave off the transversalis colli, and another small cervical branch, and at ·6″ divided into the inferior thyroid and cervicalis ascendens. The supra-scapular artery was derived from the third part of the subclavian. There was no peculiarity in the distribution of the branches of the right and left carotids.

In the arteries at the base of the brain we noted that the left vertebral was double the calibre of the right; they united opposite the lower border of the pons varolii to form the basilar, which was 1·2″ long, and curved, with the convexity to the right. The right inferior cerebellar artery was given off at the lower end of the medulla oblongata, the left ¼″ higher up. The superior cerebellar branches were given off symmetrically opposite each other immediately below the bifurcation of the basilar into the posterior cerebral.

The posterior communicating arteries were each $\frac{1}{2}''$ long and of precisely equal diameter; these joined the internal carotids ·3″ below its bifurcation into the anterior and middle cerebral, which were symmetrical. The anterior communicating arteries consisted of two small branches which interlaced, situated ·5″ from the commencement of the anterior cerebral vessels.

The distribution of the arteries of the limbs presented no important variations from the ordinary type.

Nervous System.

The brain, immediately after removal, deprived of the greater part of its membranes, weighed thirty-eight ounces.

We have already alluded to the fact of the brain of a bushwoman having recently been made the subject of an elaborate investigation by Mr Marshall[1]. In consideration of this circumstance, we thought that the interests of science would be best served by placing this additional specimen at that gentleman's disposal, and, with the sanction of the Council of the College, it is now in his hands for examination and description.

The spinal cord was not examined, as it was considered more desirable to preserve the vertebral column intact. The dissection of the nerves, although carefully made, revealed no important deviations from the ordinary arrangement.

Thoracic and Abdominal Viscera.

The whole of the left lung was firmly adherent to the thoracic walls; there were also some slight adhesions on the right side. Both lungs contained abundance of tubercular deposit, the left had several large cavities filled with purulent matter. The distinction of the lobes was completely obliterated by adhesions. The heart presented no peculiarity, its muscular parietes were flabby.

The liver weighed $54\frac{3}{4}$ ounces, and was pale and slightly fatty. It measured 10 inches from the right to the left margin, and 7 inches in the opposite diameter. Its greatest thickness was about three inches. The lobe divisions corresponded with those usually found in the human liver. The Spigelian lobe was of moderate dimensions deeply notched in the middle of its anterior border, and presented a sharp projecting angle at the left corner. At its right extremity was a rudimentary caudate lobe, but not showing any prolongation to the right, as seen in the chimpanzee, neither is the caudate lobe prominently developed, as in the orang, but rather the reverse.

The gall-bladder was small and little dilated at the fundus, being almost cylindrical when distended with air; length 4″, greatest width

[1] "On the Brain of a Bushwoman; and on the Brains of two Idiots of European descent," by John Marshall, F.R.S. *Phil. Trans.* Vol. 154 (1864), Part III. p. 501.

1″, capacity one ounce. There was no depression for its lodgement in the hepatic substance, and when distended it scarcely reached beyond the free border of the lobe.

The stomach was of the usual form, but rather capacious for the size of the individual; when moderately distended with fluid it contained 3 pints, and had a long diameter of about 11 inches. The ductus communis choledochus entered the intestine at 3¾ inches distance from the pylorus.

The small intestines measured 15 feet from the pylorus to the ileo-cæcal valve. The large intestines were 4 feet in length, and the vermiform appendix 2½ inches. The valvulæ conniventes were as well developed and extended as far in the intestines as they usually do. Peyer's patches were numerous, large and prominent, all more or less affected with tubercular ulceration, as also were various parts of the ileum, ileo-cæcal valve, and the cæcum.

The spleen was small and pale in colour, it weighed 2¼ ounces. Its greatest length was 4 inches, and greatest breadth 2¼ inches; at either end it was considerably pointed.

The pancreas weighed 1¾ ounces.

The kidneys were large, pale and bloodless, their structure appeared normal. The right weighed 5 ounces, the left 6¼ ounces, the length of the right kidney was 4·5″, of the left 4·8″.

The supra-renal bodies presented nothing unusual in appearance.

Generative Organs.

The uterus had the ordinary form of that organ in the unimpregnated female, rather smaller in dimensions than the average size as given in anatomical works, but corresponding in proportion to the general size of the body. It measured 2·2 inches long, 1·3 inch at the widest part, and ·8 of an inch in antero-posterior thickness. The ovaries were about 1·2 inch in length, the right one slightly larger than the left, and each contained numerous Graafian vesicles, while the outer, white, tough, fibrous coat had, as is often the case, numerous short deep fissures on its surface. The lips of the os uteri, especially the anterior, were very slightly pronounced. The internal length of the vagina from its external orifice to the os tincæ was two and a half inches.

The external organs of generation corresponded in the main with the description given by Cuvier. The labia majora were small. The clitoris of moderate size, but with a well-developed prepuce, and far more conspicuously situated than in the European female, chiefly on account of the want of prominence of the labia majora. The glans clitoridis had the form of an equilateral triangle, each side ·2″ long, with the base downwards. The sides of the prepuce were prolonged down into the nymphæ, which formed largely developed, lax,

pendulous triangular lobes. These were of a dark purplish brown colour, approaching to black, both without and within, except along their line of union in the vestibule of the vulva, where they shaded gradually through a light brown into a pale pink. The length of each lobe at its attached base was 1·7″; from the middle of the base to the most prominent part or apex of the triangle, when in a relaxed condition, measured 1·2″, but they admitted of considerable extension. Posteriorly they subsided into a series of slightly raised tubercles bounding the sides of the hinder part of the vulvæ. The meatus urinarius was situated 1″ below the glans clitoridis; the orifice of the vagina ½″ below that. The latter opening was circular, with a slightly raised caruncülated margin, but no other trace of hymen. The perineum was 1·25″ in length.

The remarkable development of the labia minora, or nymphæ, which is so general a characteristic of the Hottentot and Bushman race, was sufficiently well marked to distinguish these parts at once from those of any of the ordinary varieties of the human species, although they had not attained that extraordinary extent attributed to them by most authors.

In reference to this subject, the following communication, received from a scientific friend residing at the Cape of Good Hope, upon whose testimony perfect reliance can be placed, may be of interest to the anatomist.

Two pure bred Hottentots, mother and daughter, were the subjects of examination. In the words of our correspondent—"The daughter was first examined. She is about twelve years old. The glutei muscles are covered with the prominent peculiar hemispherical cushions of fat common to the tribe, and the mammary development is commencing. On standing up, two thongs of about the thickness of a cedar-wood pencil hang down from the pudendum, exactly like strips of sheepskin slightly twisted, and apparently vascular. On separating the labia, these appendages are found at once to be the nymphæ elongated, the base or attachment about half the area of what they might be expected to cover, the slight twist commencing immediately at the attachment, viz. within the pudendum. The total length of the appendage from the base to the end exactly 3½ inches. The hymen perfect. The diameter of the circular aperture to the vagina about a quarter or a third part of an inch.

"The mother has the usual falling off appearance of youth of the Hottentots of thirty years old. Mammæ flaccid and elongated. She took up her appendages, leading the right one round the right side above the gluteal projection, similarly, the left one round the left side, their ends met at the spine! I am now perfectly convinced that the organization is natural and congenital, and not produced, as has been supposed, by the degraded and filthy habits of the tribe."

ON THE HUTCHINSONIAN THEORY OF THE ACTION OF THE INTERCOSTAL MUSCLES. By Dr Cleland.

Since the appearance of the elaborate article Thorax in the *Cyclopædia of Anatomy and Physiology*, English anatomists seem mostly to have adopted without hesitation the modification of Hamberger's view of the action of the intercostal muscles which Mr Hutchinson has there enunciated:—namely, that while the external intercostals and those of the internal which are placed between the costal cartilages act only as elevators of the costal arches, the remaining internal intercostals act only as depressors. On the continent, however, there is not the same unanimity of opinion. For while some there believe that Hamberger's and Hutchinson's mechanical demonstrations afford a solution of the problem of how the intercostals act, others adhere more or less distinctly to Haller's view, that both external and internal intercostal muscles combine to assist in inspiration. Among these last are Baümler, Budge, Henle, and Wundt. Both Baümler and Budge rest their conclusions on experiments by vivisection, and the former also on observations on the human subject during life. (An abstract of Baümler's researches is to be found in the New Sydenham Society's *Year-book of Medicine*, 1862.)

If, however, Mr Hutchinson's conclusions are erroneous, and the results obtained by vivisection correct, it is much to be desired that the fallacy be laid bare which lurks in arguments considered by many as unanswerable. This appears not yet to have been done; and the following remarks are therefore offered to prove, that although it is quite true that bars fixed to a vertical prop at one end, and maintained parallel by a cross bar at the other, can be made to revolve upwards by the shortening of bands placed between them in a direction obliquely downwards and away from the prop, and to revolve downwards by the shortening of bands with the reverse obliquity, as shown by Mr Hutchinson, yet these facts lead to fallacious results when supposed to explain the action of the intercostal muscles in the living body.

It is to be remembered that in those artificial mechanisms the bars which are compared with ribs are straight, inflexible, and parallel, and revolve each on a single fixed attachment. But in the thorax the ribs are greatly curved and flexible, they do not move parallel one to another, and their anterior extremities are not freely moving ends of levers, the fulcra of which are at the vertebral column. The elevation of the ribs is not effected by revolutions of which their vertebral attachments are the centres, while their extremities move in the circumference; but rather, if we suppose a line drawn from

the head of a rib to its sternal attachment, the movement of the rib may be roughly regarded as one of revolution round that line, while the line itself slightly rises and falls at its anterior extremity. Thus the greatest movement of elevation and depression takes place towards the middle of the rib. This is easily accounted for, as the slenderness of the sternal extremities of the costal cartilages and the mobility of their articulations with the sternum cause them to yield beneath the resistance offered to their elevation; and it is only after the ribs and cartilages have so yielded, that the sternum is forced upwards at all. In ordinary respiration, as remarked by Meyer, the upper end of the sternum remains stationary, while the lower end is moved a little forwards; and in forcible respiration the whole sternum is raised, but the elevation of its upper end is slighter than that of the lower end. In the natural or artificial skeleton, movements, no doubt, can be obtained similar to those of straight wooden bars; but the method of expansion of the thorax during life is very different from the movements exhibited by handling the thoracic walls after death, and probably different even from the expansion produced by insufflation of the lungs. The reason of this is, that the expanding force is differently applied. In life, the force being applied between the ribs, each rib is supported by the one above, and the accumulated weight of all, together with the elastic tendency to redescend produced both by the tension of their position and the elasticity of the lung substance, is transmitted to the first rib, or to whichever lies above the highest of those which happen to take part in the action; hence it is that the first rib remains stationary in the ordinary respiratory movements.

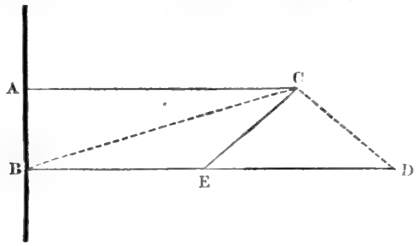
Admitting, then, as must be done, that there are many differences between the movement of the artificial mechanisms referred to and that of the thoracic walls, let us try to show in what respects the differences which exist vitiate the comparisons which have been drawn between the action of elastic bands in the one case, and the intercostal muscles in the other.

Firstly, it may be observed that, while Mr Hutchinson is no doubt quite right in regarding the sternal articulations as fulcra on which the costal cartilages move in inspiration, it is a mistake to select the costo-cartilaginous articulations as the points where movement on the sternal fulcrum meets with movement on the vertebral fulcrum. The point of freest motion of the rib ought rather to be looked on in this light. But the point of freest motion is placed about the middle of the costal arch; and therefore the argument that the internal intercostals between the cartilages raise them round the sternum in a way similar to that in which the external intercostals raise the ribs on their vertebral attachments, is applicable to the internal set as far back as the middle of the costal arches. Thus, were we

to admit the soundness of the principle on which Hamberger and Hutchinson have argued, it would yet appear that the internal intercostals have a larger share in producing the elevation of the ribs than Hutchinson has allowed. On this, however, it is unnecessary to lay much weight, as other considerations will show that the principle is erroneous.

Secondly, the diagrammatic schemes and apparatus with oblique bands used to demonstrate the depressing effect of the internal intercostal muscles do not show, or rather are not used to show, the effect of similar bands when the upper bar or rib is fixed.

Now, let AB represent a portion of the vertebral column; and let AC and BD represent the posterior parts of the first and second



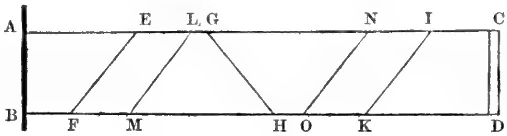
ribs, as seen from behind; and let CE represent an internal intercostal fibre. If AC be immoveable it is quite plain that the internal intercostal CE will tend to raise BD until it shall lie in a straight line with it in the position of BC; for then it will form with BE the base of the triangle of which in any other circumstances it and BE would be the remaining two sides. Therefore when a rib is at rest in the most depressed position which its attachments admit, as the first rib usually is, the contraction of the internal intercostal muscles helps to raise the rib below. Again, if AC be pulled upwards with a greater force than CE pulls it down, it will both be elevated, and by means of CE will draw BD after it; if the uniting band CE were an inelastic ligament it would draw BD out of its parallelism to AC and cause it to approach that bar, but being muscular it will by contraction cause the approach to take place still more rapidly; and even if the elevation of the upper bar be so great as to make the increase of the distance between C and E a mathematical necessity, a muscular band, while compelled to yield, will yet have power to maintain the lower bar in as close approximation as possible to the upper.

Thirdly, it is to be observed that in the upper part of the thorax the costal arches rapidly increase in size, in the series from above downwards; the second being greatly larger than the first, and the third larger than the fourth, and so on in less degree: and while at the posterior part they are nearly vertically superimposed one on

another, at the sides and in front they are related quite differently. Now in the diagram already used, while AB still represents the vertebral column, let C and D represent upon two upper ribs points in one vertical plane and situated in any part of the course of the ribs in which the line uniting such points is oblique. It is at once seen that the line CD is in the same position as a band representing an external intercostal muscle in one of Hutchinson's mechanisms of bars, and will similarly be shortened by the parallel ascent of the lines AC and BD and lengthened by their descent. Thus while no doubt the spaces between the ribs are all widened at the back part in parallel elevation of the ribs, those near the top of the chest are in the greater part of their extent narrowed in parallel elevation, and of course are still further narrowed when the elevation of the lower ribs exceeds that of the upper. In these spaces both the external and internal intercostals pull the larger hoops towards the smaller, but inward motion of the larger hoops is prevented by the nature of their attachments, and their approximation to the smaller hoops is therefore effected solely by elevation.

Fourthly, an examination of the modus operandi of the results of the experiments made with straight bars will enable a more accurate estimate to be made of the relations in which they stand to the actions of the intercostal muscles.

Let GH be an elastic band stretched between AC and BD which represent two bars kept parallel by CD, and moving on the fixed



fulcra A and B. The band GH pulls the point G downwards with exactly the same force with which it pulls the point H upwards. But it acts upon BD with greater leverage than upon AC, therefore BD is pushed upwards more strongly than AC is pulled downwards. In consequence of this, BD will overcome the pressure downwards of AC, and will push AC upwards as long as the difference between the force exerted on AC and that exerted on BD is sufficient to overcome the resistance of the moving part of the apparatus; this difference diminishing as the forces themselves are diminished by the lessening elastic energy of the shortening band GH. Thus also the same bars would be pulled downwards by a band at EF, simply because the lever AE is longer than BF, and if AE be twice as long as BF the downward force exerted on the upper rod will be twice as great as the upward force exerted on the lower rod. But if the band EF be moved to IK and have

there the same slope as before, the approximating strain upon the parts of the rods intervening between it and AB will be greatly increased by the increased leverage, while the difference between the two levers will remain unchanged, and therefore the force with which the bars are driven downwards will be likewise unchanged. Further, let the space between EF and IK be filled with closely lying parallel oblique bands; let LM be a band so situated that BM shall be equal to AE; and let NO be so situated that AN shall be equal to BK. The downward force exerted on AC by the bands attached between E and N will be exactly equal to the upward force exerted on BD by the bands attached between M and K. Therefore the total force with which the joint action of all the bands pulls downwards the upper bar exceeds that with which they pull upwards the lower bar merely by the difference between the action on the lower bar of the bands from NO to IK, and that on the upper bar of the bands from EF to LM.

The bearing of these remarks on the movements of the thorax is easily explained. Although it is not the case that so great a number of the internal intercostal fibres have their points of attachment withdrawn one from the other in inspiration and approximated in expiration, as Mr Hutchinson supposes, his statement is no doubt true of many of them. Now, if the fibres so situated are in other respects circumstanced like the elastic bands supposed to fill the space between the lines EF and IK in the diagram, they will drag down the rib above more strongly than they will pull up the rib below, but the difference of strength with which they act on the two ribs will be extremely small; for if EF represent the most posterior, and IK the most anterior of the muscles now referred to in any intercostal space, then the total difference between the upward pulling and the downward dragging of the whole, being equal to that between the upward action of the muscles from NO to IK and the downward action of those from EF to LM, cannot, on a moderate calculation, be more than the difference of action of about half a square inch of muscle in these two situations. This then is the total energy with which the internal intercostals in any space can imitate the depressing action of the elastic band on the wooden bars: and if they imitate that action at all, then the depressing force exerted on the upper rib is conveyed through the highly yielding costal cartilage of that rib, mediately or immediately, to the tip of the costal cartilage of the lower, whereas it is obviously one of the requisites for success in the experiment with bars that the bars be unyielding, or at least yield less easily than the apparatus is depressed. Leave the yielding of the costal cartilages out of the question, and it remains that if the internal intercostal muscles depress the ribs after the same fashion as the elastic band depresses the bars, then all but a minute fraction of

their power is utterly wasted, giving no aid in producing the depression, but merely binding the ribs together.

But it will be replied, that still the fact remains that at least many internal intercostal fibres have their attachments actually approximated in expiration and withdrawn in inspiration. The answer is, that this is admitted, and that the bar-apparatus illustrates the circumstance: a diagram will do so also, without complicating the matter with the delusive depressing action of the india-rubber bands on the bars. Moreover, the direction of the internal intercostal muscles is really calculated to be highly advantageous in forced expiration; only the action is of the formerly recognised and easily understood description, that the lower ribs are kept firmly down, while those above are pulled towards them; and the advantage of the direction of the internal intercostals in these circumstances is that the more depressed the ribs, and the less the remaining contractile energy of the shortened muscles, the more nearly do the muscles lie at right angles to the ribs. But it does not follow from the shortening of the distances between the attachments of these muscles in expiration, that they are always then in action. If the depression of the ribs is occasioned by their own elasticity and that of the lungs, and by the weight of the parts, which seem to be causes quite sufficient to effect it, it is quite possible for the muscles to remain relaxed while their attachments are approximated, which is what the vivisectors appear to have found. On the other hand, it does not follow that because the muscles are elongated in inspiration, they therefore take no part in aiding that act; for, as has been said, they may be most useful in pulling up lower ribs when those above them are independently raised; their action in those circumstances being of the tonic ligamentous description spoken of with reference to the long muscles in my paper in the previous number of this *Journal*.

The four arguments now adduced, but especially the last, render necessary the abandonment of the Hutchinsonian theory of the action of the intercostal muscles, by showing that the supporters of that theory have overlooked most important circumstances, the consideration of which entirely vitiates the arguments on which it is founded.

In the second argument and in the preliminary remarks, allusion has been made to the comparatively slight movement of the first costal arch during life compared with that of the arches following; and it will naturally occur to any one, that if the first rib be pulled on sufficiently strongly by the intercostals in the spaces below drawing up the succeeding ribs towards it, the tension on the first rib may even be so great as to cause it to be depressed below its natural level, by bending; and accordingly one would expect to find cases of difficult breathing in which the upper end of the sternum is depressed

instead of elevated in inspiration. This at least had occurred to my mind, and it was therefore all the more interesting to meet with a patient in which such depression actually took place, especially as it happened after this paper had been written. The patient was a boy aged 18, who had suffered more or less from chest complaint for three years and a half. He afterwards died, but unfortunately there was no opportunity of having an examination of the body. However, he had obviously very general tuberculosis in both lungs, and probably extensive adhesion of the pleura on both sides. His chest was remarkable for its peculiar shape. The sternum, which was rather concave from above downwards, projected greatly at the lower end, and the fifth, sixth, seventh and eighth costal arches presented a concavity at the junction of the rib and cartilage, giving rise to the chicken-breasted variety of deformity. In ordinary breathing, when carefully watched, the sternum was seen to move peculiarly; for in each inspiration the upper half of the sternum was depressed at the same time that the ribs were elevated and the lower half of the sternum projected by the lower ribs. In expiration, elevation and advance of the upper end of the sternum immediately succeeded depression of the ribs; the cause of this no doubt being, that as soon as the intercostal muscles were relaxed the first rib sprang back into its normal position. By placing two fingers on the first and second ribs in inspiration, the first rib was felt descending while the second rose and lay more superficially to it: in expiration the reverse occurred. Thus the second rib lay principally in front of the first in inspiration, and below it in expiration. Although, as far as I know, this case is singular, still it seems probable that, if looked for, similar cases may be found not unfrequently. The patient, it may be mentioned, was of slender build and emaciated, so much so, indeed, that every effort at deep breathing was instantly prevented by the closure of the windpipe from pressure of the air on it above the sternum, in a manner similar to what is recorded by Allen Burns as having occurred in a patient after abscess at the root of the neck (*Surgical Anatomy of Head and Neck*, p. 6).

In the third argument of this paper the sternal attachments of the costal cartilages have been spoken of as preventing the larger costal arches from being pulled inwards below the arches above them. I have also had the opportunity of seeing this point illustrated pathologically in a very remarkable manner. A woman operated on for cancer of the breast had return of the disease in the sternum. As the disease progressed the sternum was snapped across between the second and third ribs, and ultimately was quite destroyed except at its upper extremity and cartilaginous lower end, so that shortly before death, while the first costal arch remained intact, the succeeding costal cartilages were denuded and separate, with small portions

of sternum adhering to their free extremities. In every expiration these extremities stood out from the chest, while in inspiration not only were they pressed in, but they were turned backwards and the fore part and sides of the chest were coiled violently inwards, so as to approximate the sides of the wound, and make the chest appear rather contracted than expanded. Respiration was thus rendered extremely exhausting, and the patient died within two or three days after the condition described had been established; yet notwithstanding the difficulty of breathing which had been exhibited, on examination of the body the lungs were found anæmic and perfectly healthy. Doubtless the enlargement of the thoracic cavity in inspiration had been effected entirely by the diaphragm, or nearly so; and it is evident that the contraction of the diaphragm would be sufficient to cause the weakened front of the chest to yield before the pressure of the atmosphere, and would drag inwards the circle of its costal attachments; but it would be inadequate to producing the extraordinary rolling-in of the extremities of the loosened sternal ribs. This movement however is completely explained by the consideration that the intercostal muscles must necessarily pull the larger arches in under the smaller; although perhaps it would scarcely have occurred to any one to have predicted that their action would have been so remarkable as that which was exhibited in the case described.

RESEARCHES ON MUSCULAR IRRITABILITY AND THE RELATIONS WHICH EXIST BETWEEN MUSCLE, NERVE AND BLOOD.

By RICHARD NORRIS, M.D., *Professor of Anatomy and Physiology at Queen's College, Birmingham.*

MUSCULAR irritability is commonly recognized and defined as that property of muscular tissue by virtue of which it contracts under the influence of stimuli.

This property is said by Du Bois Reymond to bear a definite relation to its electro-motor powers: he says, "The diminution of the muscular current after death is proportional to the diminution of the excitability of the muscle; both the electro-motor force and the excitability have the same termination, i.e. in the rigor mortis, caused, as Brueck has proved, by the coagulation of the fibrin contained in the muscles external to the blood-vessels." As a general summary of his researches on this question Du Bois Reymond again says, "The electric power of a muscle is always proportioned to its contractility, inasmuch as those agents which do not influence its contractility exert no influence on its current."

Matteucci has asserted, "That the muscular current continually decreases *after the death of the animal*, or after the *separation of the muscle* from the body[1]."

Taken in concert these statements of Matteucci and Reymond amount to this—muscular irritability continually decreases after the

[1] By the death of an animal the author of this paper understands the loss of the property of excitability or neurility on the part of the ganglionic nervous masses, without power of restoration; in fact, molecular death of the vesicular nervous tissue. It is certain that the phenomena of life as manifested by animals may be again aroused into exhibition so long as the *capacity* for molecular life persists in the nervous system, notwithstanding that both respiration and circulation may have long ceased. In a chapter on death, p. 905 of Carpenter's *Principles of Human Physiology*, the following passage occurs: "A surer test, however, is afforded by the condition of the *muscular* substance; for this gradually loses its irritability after real death, so that it can no longer be excited to contraction by electrical or other kind of stimulation; and the loss of irritability is succeeded by the appearance of cadaveric rigidity. So long then as the muscle retains its irritability and remains free from rigidity so long we may say with certainty that it is *not dead;* and the persistence of its vitality for an unusual period affords a presumption in favour of the continuance of some degree of vital action in the body generally; whilst on the other hand the entire loss of irritability and the supervention of rigidity afford conclusive evidence that death has occurred."

On this the present writer would remark, that although the persistence of muscular irritability affords strong presumptive evidence of the existence of systemic life, yet it cannot be invariably relied upon, inasmuch as the irritability may in cases of excessive interstitial change increase after the *molecular death of the nervous masses and the final arrest of the blood-current.* On the other hand, universal rigor mortis, the result of the absence of blood or suitable nutritional plasma, is a certain evidence of death whenever the circumstances of the case imply that the nervous system has also been subjected to

removal of a muscle from nervous and blood influences. This view of the gradual decline of muscular irritability after somatic death is concurred in by physiologists generally. Certain researches in which the author of this paper has been long engaged have led him to doubt the accuracy of this conclusion as a necessary and fundamental truth.

As the consideration of the subject opens up a considerable range of experimental enquiry, it is conceived that it may be most efficiently discussed in its various bearings by an attempt to support the following propositions, mainly derived from the study of phenomena which are best and most constantly seen in cold-blooded animals, but which nevertheless under favourable circumstances may be observed in warm bloods, and in special pathological conditions in the case of man himself.

1. That the property of irritability in muscle is capable of a high degree of exaltation above the normal standard, and that the highest degree of susceptibility is attained in cold bloods long after death, or under conditions tantamount to death as before defined.

2. That the forces of nerve and muscle, the neurility of the former and the irritability of the latter, are not only independent of each other for their existence and maintenance, but actually possess an antagonistic relation; that is to say nerve tissue, instead of producing, is, when in action, constantly concerned in maintaining a condition of things which diminishes muscular irritability, and that not simply when it is engaged in the production of motion. Hence muscular tissue, relieved from the operation or influence of nerve tissue, gradually acquires exalted contractile powers either in the presence or absence of the blood.

3. That the blood, or the nutritional plasma derived therefrom, not only furnishes the materials by which muscular irritability is maintained, but is likewise the determining cause of that polar arrangement of the muscular molecules which maintains or restores the elongated or relaxed state.

It is a well observed fact in physiology that after the death of animals the irritability of the muscles frequently exhibits itself in an abnormal manner. In the living animal or the amputated limb the contractions which are inducible by the application of stimuli, such

a simultaneous absence of its *proper* nutrition, inasmuch as it appears to be a law without exception, that if muscular and nervous tissues be simultaneously shut off from their source of nutrition, the molecular life of the nervous tissue is the first to succumb. It is however possible to conceive of certain spasmodic affections of the minute arteries supplying muscular tissue, in warm bloods, inducing rigor rapidly, in the same manner as deligation of arterial trunks, and if at the same time it should happen from any collateral circumstance that this condition of vascular spasm did not extend to the nervous masses, somatic death would not necessarily be implied even by the existence of rigor. Universal putrescence is therefore the only *absolute* evidence of death.

as galvanism, pinching, or striking, are of a pulsatory character, that is to say, the contraction is limited in extent and speedily gives place to relaxation; but in the cases where the peculiarity alluded to is present, the contractions following on such stimuli are more extensive and persistent, and simulate very perfectly contraction induced by volition. The same peculiar exalted susceptibility has also been witnessed in man, after death from certain forms of disease, more particularly in cholera and yellow fever.

Dr Bennett Dowler by experimenting upon amputated limbs proved this abnormality to depend upon muscular irritability alone. It is asserted that in some of these cases not only can the movements be excited by mechanical stimulation, but that they not unfrequently occur spontaneously, and strongly resemble the actions of the living state. Carpenter quotes the case of an Irishman, aged 28, in whom the following series of movements took place spontaneously not long after the cessation of the respiration: "First the left hand was carried by a regular motion to the throat, and then to the crown of the head; the right arm followed the same route on the right side; the left arm was then carried back to the throat, and from thence to the breast, reversing all its original motions, and finally the right hand and arm did exactly the same." This hyper-irritable condition of the muscular system attracted the notice of Dr Brown Sequard, and he found it to present itself more constantly in young animals. This experience of Brown Sequard's is conformable with my own, but I have also been fortunate enough to observe it in cold bloods with sufficient frequency to enable me to study it. It is well-known that in many particulars the young of warm bloods are analogous to the cold bloods; and one of these is the length of time that muscular irritability persists.

I will now cite two or three experiments in illustration of this exalted state.

April 7th, 1863, a frog carefully ætherized was placed upon his back, and the heart was excised. The frog was then left till the following morning, a period of thirteen hours: at this time the webs and toes were in a dried state, but the muscles responded with extreme readiness to slight blows, but were not thrown into contraction when pinched by forceps. They were very susceptible to weak galvanism.

These observations on the muscular system having been made, the nervous system was tested by removing the head and attempting to irritate the cord. Galvanising the cord would not excite the muscles, even when a copper wire was thrust low down into its substance. The cord, in fact, seemed quite incapable of either initiating or conveying any stimulus to the muscles. The sciatic nerve was now raised upon a glass tube, and it was found that it could not be excited by the strongest galvanism. The neurility or special life of the

nervous system was in fact gone, *while the peculiar life of muscular structure, viz. its irritability, had become preternaturally exalted.*

Another frog having been ætherized till incapable of exhibiting any reflex phenomena, that is to say, until the nervous system was temporarily extinguished, the muscular system was still under these conditions highly sensitive to galvanism. The frog did not recover from the ætherization. It was allowed to remain all night; and its muscles were still found susceptible to galvanism in a high degree, *but not to other modes of stimulation.* The nervous matter of the cord was now broken down and removed, and the body placed in a little water to prevent desiccation. It was again left all night, and on the following morning the muscles were found to be *exceedingly susceptible to slight blows or pinchings, including not only the skin but also a small portion of muscular substance. These motions simulated, in their extent and power, volitional movements. They were excited with the utmost ease, and seemed to ordinary observers to be purposive acts resulting from sensation.* These effects were observed thirty-six hours after the ætherization of the creature.

May 18th, 1863, a frog having died in spawning, the muscles were found to be somewhat susceptible to slight blows and very susceptible to galvanism. A portion of the calvarium was removed so as to allow the brain and cord to be tested. A copper wire was thrust into the canal, and an attempt made to galvanize the cord, but with no result; neither did any contraction take place during the final destruction of the cord. In fact, the nerve-tissue was dead, and could not be stimulated. This frog being left in this condition for fifteen hours, the muscles of the thigh of one limb were found to be peculiarly susceptible to the influence of both slight blows and galvanism, and when a contraction was excited, the *limb was forcibly raised or drawn up, and remained so for several seconds.* After a few minutes' experimentation, in which many contractions were produced, *the force appeared to be exhausted;* hence it seemed that the force which confers contractility *had accumulated to a certain pitch or intensity, and was used up in the act of contraction.*

The following is a more recent observation from my experiment book.

9 A.M. Aug. 13th, 1866. "On taking up this frog, *now dead,* and touching the limb, which during life had been paralysed by section of its nerve, with my finger, *it was suddenly shot out as if alive.* I placed the body down, and one or two *apparently spontaneous movements* of small extent afterwards occurred. On touching the skin gently with the point of a needle, by the slight pressure upon the muscle beneath movements of the limb were also induced, *but this high degree of exaltation very rapidly disappeared,* after which the muscles were found ordinarily sensitive to galvanism." It is necessary

to state that the limb exhibiting these effects had been paralysed so far as nervous influence is concerned for sixty-three hours, and deprived of blood for at least six.

We have here then three examples in which this phenomenon has been produced artificially, and one in which it occurred naturally. *In all of them the leading feature is that the nervous and vascular functions ceased to exist long prior to the production of the exalted state of the muscular system*—in one case 13, in another 15, in a third 36 hours, and in the last example nervous influence was absent for 63, but blood for 6 hours only. We must not hastily infer from these experiments that it is simply necessary to destroy these functions in order to secure this hyper-irritable condition of the muscular system.

It is needless to say that cold bloods may be destroyed in numerous ways which altogether prevent the exhibition of this peculiarity. Thus if the head be crushed the condition of the nervous system which arrests suddenly the action of the heart appears also to impair the powers of the general system of muscles, and causes rigor to supervene at a comparatively early period.

Again, in death by strychnia the irritability of the muscles is diminished, and they pass quickly into the state of rigor, the flexors of the hind limbs prior to the extensors.

In death by CO^2 the irritability is depressed, and rigor comes on quickly.

Muscles subjected to chlorine lose their irritability very quickly indeed, and the state of rigor follows more rapidly than in any of the other cases.

Prolonged action of weak æther vapour removes every trace of irritability, and paves the way to early rigor.

Again, if after the section of the spinal cord at the junction of the atlas and occiput the creature can still control his limbs (as frequently happens with frogs), the post-mortem exaltation of the muscles will be much less likely to occur than if the section was lower down so as to completely paralyse them[1].

[1] In the existing condition of neural physiology it may perhaps be desirable to offer some explanation of the above remarks. To those who are practically engaged in physiological experiment it must be apparent that our present views of the functions of the cerebro-spinal system await considerable modification if not reconstruction. Certain it is that to deprive *some* vertebrates of their *entire cerebral organs* is by no means to destroy their capacity for willing and feeling. To Mr G. H. Lewes belongs the credit of having first prominently brought forward this highly important fact in an admirable and logical essay on the nervous system, to be found in his second volume of *The Physiology of Common Life*. Since perusing this essay I have repeatedly made experiments upon the matter, both in private, and publicly before my class and colleagues, with the most unequivocal results. The matter is so important that I may be pardoned the insertion of an illustrative experiment. On March 30th, 1863, 9.50 A.M. I struck off

The general deduction warranted by the experiments seems to be that any mode of death which tends to interfere with the processes generating muscular force, either by acting directly on the muscular tissue, or indirectly by exciting the nervous tissue to the consumption of muscular force, is opposed to the production of this exalted state. On the other hand, modes of death which quickly destroy the nervous system, by sedation or by withholding its nutrition (blood), and at the same time do not interfere materially with the muscular, seem favourable to its production.

The extensive character of the contraction which takes place during this exalted state of muscular tissue appears to result from a

with a sharp chisel the head of a frog. At 10 o'clock the creature *spontaneously* drew up its extended limbs into the normal flexed position beneath its body, and then *moved itself* round in a circular manner three or four times. It then remained quite still for five minutes, and then again turned round a fourth of a circle after the fashion of the unmutilated animal. At 10.8 made another turn, and afterwards commenced to *move freely about the table as if very little had happened.* 10.40. This frog has executed several *spontaneous* leaps. At 11.45 I found it still sprawling about. If in leaping it came down on its back, which it seemed liable to do, by struggling it soon righted itself. 1.20. This frog is even more vigorous and leaps and moves about more freely than before. I now cut off the upper portion of the spinal column and included cord; the frog was tremulously convulsed, but after a short time drew up its limbs and *moved again spontaneously.* The removal of the last portion put a stop to the action of the larynx. Of such experiments as these I possess numerous records, but the above is sufficient for our purpose. It will occur to the reader that Marshall Hall laid particular stress upon what he deemed to be a cardinal fact in neural physiology, viz. *that no spontaneous movements ever occurred in decapitated animals.* On the truth of this observation he based his theory of reflex or excito-motory action. The arguments of Dr Hall may be briefly summed up thus: If cold-blooded animals or the young of warm bloods be decapitated or their brains removed, irritants applied to their bodies will still induce movements; that the animals have lost the power of volition is maintained on the ground *that they perform no spontaneous movements;* and inasmuch as volition is the *second link* in the chain of which sensation is the *first* and motion the *last*, the creatures cannot possess sensibility, therefore the movements which follow irritation, however purposive or adapted to ends they may seem, are not the result of either sensation or volition, inasmuch as these are properties of the brain alone, therefore they result from a purely mechanical arrangement the principle of the operation of which is that any excitation applied to the extremities of sensory nerves is conveyed to the nervous centre and there reflected on to a motor nerve, which in its turn stimulates muscle into action, *no sensation whatever being perceived.* In respect to these opinions of Dr Hall I would remark, that whether or no the absence of spontaneous movement proves the absence of volition, it is quite certain that the converse is true, viz. that the presence of spontaneous movement proves the existence of volition, and, as seen in the above experiment, the decapitated trunk gives all the evidence *we can have or ever do have* of the possession of both volition and sensation, the whole theory of Marshall Hall is completely disproved and subverted, and the brain can no longer be regarded as the exclusive seat of these powers. In order to secure success in these experiments certain precautions are necessary. 1. No anæsthetic should be used, as it materially decreases the chance of recovery. 2. The hæmorrhage must be trifling. 3. The nervous tissue must be cut, not crushed. To achieve these conditions the angles of the mouth should be slit sufficiently far back to allow of the removal of the head by means of a sharp chisel, the lower jaw, tongue and principal vessels are then uninterfered with.

propagative action; e.g. in the most sensitive state it is simply necessary to include the smallest portion of a muscle within a pair of forceps, or to touch a single spot with the point of a fine needle, to excite contraction in a considerable portion of the muscular mass, as in the case of the heart a few fasciculi immediately subjected to stimulation contract, and in the act excite contraction in contiguous fasciculi; and in this way the effect rapidly spreads throughout the muscle, and by calling into play a large number of elements induces a marked and continuous contraction allied to that produced by the medium of the nerves.

The nervous stimulus seems to differ from other modes of stimulation in the effect produced, mainly in the fact that it can call at once into effective action considerable masses of muscular structure by virtue of the minute distribution of its filaments among the muscular elements. In the case before us a similar effect seems to be brought about by a preternatural degree of excitability on the part of the muscular tissue itself.

In dealing with my second proposition, it is not my intention to recapitulate the many arguments which have been adduced to show the independence of muscular irritability of nerve force. I wish simply to demonstrate that in all cases where nerve influence may be considered in active operation there is a diminution of muscular irritability, and that conversely when that influence is cut off from muscle, there is a tendency in the muscular force to accumulate. In all animals there is a marked distinction in the states of the nervous and muscular systems during mental activity and the condition in which volition is cut off from its nervous associations. By the state of mental activity I mean simply the waking state of an animal in contradistinction to the condition which obtains during profound sleep, fainting, or complete ætherization.

During the waking state the muscular system of an animal is maintained, through the medium of the nervous, in a condition of slight contraction, in which the muscles firmly balance or steady each other; and thus the will holds firm possession of the muscular organism. It would appear that this active volitional state involves a constant expenditure of neuro-muscular force. In profound sleep and allied conditions this psycho-neural influence ceases to operate upon the muscular system; hence we find the head fall forward upon the chest, the arms sink down, the fingers relax, if the person is standing he may fall down, or if sitting slide from his chair, the eyes become closed, &c.

In fainting and death the same powerless flaccid condition of the muscular system is seen in excess; yet in all these cases the elasticity and irritability of the muscular system still exists.

Sleep, fainting, deep ætherization, and death, seem to represent

different degrees of what may be called functional neural paralysis, in contradistinction to purely muscular, in which the irritability of the muscular tissue is diminished or gone, while the neurility of the nervous centres and nerves remains.

When we reflect that the mere waking state of animals involves a constant expenditure of both nervous and muscular force, the importance of sleep for their reaccumulation becomes obvious. It is not therefore alone in the production of motion that the will consumes neuro-muscular force, but also in the maintenance of the normal position of the animal; for few muscles of the body are during the waking state in a condition of non-control or laxity; most are subjected to continuous stimulation of a mild form. In the tremulousness of old age, or after exhausting disease, we witness the effect of deficiency of this tonic power.

Whenever the mind has to make a greater effort than usual for the accomplishment of an act, it is an evidence that the forces of the system are below par, and do not respond with their accustomed delicacy to the influence or stimulus of the will; and in such cases the animal is said, in common parlance, to be tired or fatigued.

The degree of stimulation exercised by nerve upon muscle may be normal or abnormal; and in proportion to the severity of the stimulation will be the rapidity with which irritability will be consumed, and rigor mortis supervene.

There appear to be three conditions of nerve in respect to the muscular tissue.

1. It may exist as a mere structure, i.e. functionally inactive.

2. It may be in that condition which enables an animal so to control its limbs as to maintain any required position.

3. It may be concerned in producing actual movement. The last two conditions appear to be degrees of the same kind of action.

We wish to ascertain by direct experiment whether all or any of these conditions of nerve are concerned in exhausting muscular irritability.

This is by no means an easy matter; for although we have abundance of experimental evidence from the negative stand-point, that irritability is *exalted* in the *absence* of nerve influence, it is difficult to devise reliable experiments in support of the positive proposition.

The reasons of this will become more obvious as we proceed to review the interesting experiments which clear the ground. It will be well to bear in mind the conditions necessary to a successful experiment, as the bearing of the after remarks will be more apparent.

1. The source of irritability, viz. the blood, must be cut off from two symmetrical limbs of the same animal.

2. The possibility of nervous supply must be cut off in one limb and retained in the other.

Three animals (in all respects similar) so situated must be taken.

One must be placed under conditions which enable the limb with the nerve intact to remain in a flaccid, uncontrolled state, equivalent to the condition of volitional paralysis.

Another must be caused to maintain continuous control over the limb without the induction of motor acts.

The third to exercise the limb and contract the muscles.

These conditions being achieved, we have to note in which of these cases rigor mortis of the limb supplied with nerve sets in earlier than in the other limb deprived of both nerve and blood. This will furnish us with the comparative *rate* at which the irritability is exhausted in limbs so situated.

The next question is, whether such an experimental combination is possible.

At the very threshold an insurmountable obstacle meets us in the case of warm-blooded animals; for in them to cut off the supply of blood is to induce immediate paralysis, which is rapidly succeeded by the condition of rigor mortis. This is well illustrated in the effect of deligation of the abdominal aorta. During the early stages of the paralysis thus induced in the hind extremities, both the nerves and muscles are susceptible to the stimulus of galvanism, and sensation is likewise perfect. Why, therefore, is it that volition is unable to influence these limbs? The same and similar experiments upon cold bloods enable me to answer this question. I find that if, in these creatures, the circulation be cut off from a limb in which the nerve is still allowed to remain, the *paralysis is not immediate, in fact, does not come on for a period of from one to three hours,* the frog during this interval being able to use the limb; but at length we get the same condition of complete paralysis which obtains at once in the warm bloods.

The following experiment will illustrate this.

August 11th, 6 P.M. 1866. A large frog was taken and thoroughly ætherized, the artery supplying one of the hind limbs was taken up and tied and then cut below the ligature. The ligature was applied to prevent general bleeding. The nerve was then raised up out of the way, and the whole of the structures of the thigh were cut through to the bone leaving the nerve intact—the skin was then brought together with sutures. In rather over an hour the frog began to respire, and I found he possessed sensibility in the limb, and was also able to move it a little.—10 P.M. The frog seemed to have complete control over the partially amputated limb in all those muscles still possessing bony connections.—8 A.M. Aug. 12th. The limb was found to be completely paralysed, but quite flaccid. It possessed very little irritability, quite a marked difference in this respect between the two limbs. The limb is now dragged after the body at full length. *Its*

sensation appears perfect.—4 P.M. The *paralysed limb is now void of all irritability,* as tested by galvanism. It *is however still flaccid,* and *the sensibility to pain normal.*—9 A.M. Aug. 13th. The paralysed limb is now in *a state of rigor,* and *there is an entire absence of sensation.*

In this case, as in others of the kind, we observe there is a gradual diminution of muscular irritability; but this will not account for the paralysis, for we have many examples in which frogs would move their limbs by volitional effort where the muscles are far less irritable, and rapidly passing into a rigid state; such examples are furnished by certain stages of thermal tetanus. The following experiment will throw light upon the real causes of the paralysis.

August 10th, 4 P.M. Compression was exercised upon the abdominal aorta of a frog. It was then ascertained by the microscope that the circulation in the limbs was completely arrested. The sciatic nerve of one limb was then divided. The paralysis of this limb was complete. *The creature had perfect control over the limb deprived of blood, but with the nerve intact.* In about an hour afterwards it was observed that although quite vigorous *it had lost all control over this limb.* I tested the muscles of both limbs for irritability, and found them in both cases tolerably sensitive. The distal extremity of the cut nerve is also irritable.—10 P.M. The limb possessing its nerve remains perfectly paralysed, and is, with the other limb, dragged after the frog at full length. The torniquet was now removed from the aorta and the creature placed in water. At this time the muscular irritability was at a very low ebb. At 8 A.M. Aug. 11th, the frog was much in the same condition; the limb in possession of its nerve and artery was still completely paralysed, although the muscles of both limbs had acquired increased susceptibility to galvanism. On examining the webs I found a free circulation now going on in both limbs. The sensation in the skin of the paralysed limb possessing the nerve is perfect.—1 P.M. No return of motor power in the anatomically perfect limb.—9 A.M. Aug. 12. The limb is still paralysed, but the muscles are *very irritable, in fact, more than normally so.* At 8 A.M. Aug. 13th, the frog was placed under the influence of strychnia, to ascertain if the nervous impulses generated by the drug would pass over the nervous obstruction and contract the highly irritable muscles. Not the slightest effect, however, was produced. This experiment shows that in thus cutting off blood from a limb we interfere seriously with the functions of the motor nerve; and as in animals deprived of blood the excitability of nerve-tissue is always first to perish, it is legitimate to assume that this degradation of the nerve is the primary effect of cutting off the blood from a limb, and therefore the cause of the paralysis. This functional degradation of the nerve being brought about immediately in warm bloods, and

gradually in cold bloods, is consistent with all our knowledge of the differing degrees of vital persistence possessed by these classes respectively. The experiment further proves that the nerve may suffer past restoration by prolonged absence of blood, but that the muscular irritability may be completely restored, in fact exalted.

The question as to the part of the motor nerve (the trunk or the terminal branches) concerned in the paralysis is one of extreme interest. Inasmuch as the sensory fibres still convey their impressions, it seems probable that the defect in the nerve must lie in its ultimate distributions to the muscular tissue; otherwise we should have to consider that the motor fibres of the trunk of a nerve are dependent upon the general circulation of a limb for their integrity, and that the nutrition of the sensory fibres of the same trunk is maintained in some other way. There seems to be a remarkably interesting analogy between this form of paralysis and that induced by the action of the woorara poison[1].

Comprehending now more fully the nature of the paralysis which results from depriving limbs of blood, we are in a position to see that whatever influence nerve may exercise in exhausting irritability when the source of its replenishment is cut off must *necessarily be exercised prior to the accession of the paralysis,* for this form of paralysis affecting the ultimate distributions may be considered as equivalent to the absence of nerve tissue; and under such circumstances the irritable muscular tissue represents the condition and capacity of living muscle freed from nerve influence.

It is clear then that as the terminal distributions of the nerves to the muscles of warm bloods *become at once insensible to the stimulus of volition,* that the nerve in these cases can have no influence in hastening rigor by exhausting irritability, and the accession of rigor mortis here must therefore be referred *entirely to absence of blood;* for in these cases we are not even disturbed by speculations as to the possible influence exercised upon the muscle by the *mere presence* of living nerve tissue in a state of inaction.

We see then that the question with which we started is one capable of solution only by experiments upon *cold bloods* carried out in the manner previously indicated; *for in these only is it possible for nervous influence to act upon muscular irritability in the absence of the blood,* and in these for a limited period only, but, nevertheless, sufficiently long to prove whether or no the *mere presence of inactive living nerve* diminishes muscular irritability, or whether the loss of irritability is appreciable only when the muscle is either *controlled*

[1] How is it that the terminations of the motor nerves in muscles are so interfered with while neither the trunk or its ramifications nor the muscular tissue appear to be affected past restoration? Is there any intermediate tissue differing from nerve or muscle which forms the bond of union between them?

or induced to contract by nervous influence. Space will not permit me to recite the complicated experiments by which the necessary conditions were achieved, and I must content myself in this place by briefly stating the deductions arrived at.

1. Mere presence of living nerve in a state of inaction neither hastens nor retards the accession of rigor, and therefore has no influence on irritability.

2. The condition of nerve concerned in simple muscular control and in contraction leads to earlier rigor mortis, and therefore possesses the power of exhausting irritability.

Leaving now this aspect of the question, we proceed to enquire what evidence do we possess that muscular irritability is capable of abnormal exaltation in the absence of nerve, or in those uncontrolled powerless states of the muscular system which, from the absence of volitional impulse, are equivalent thereto?

Firstly, we have the fact that if one limb of a frog be paralysed by section of its nerve, *after a certain period has elapsed* it will be found more susceptible to the various forms of external stimulation than the other limb; and if such an animal be killed or happen to die, the limb in which the nerve is intact will lose its irritability and pass into the state of rigor, long prior to the limb the nerve of which has been divided.

Dr Radcliffe remarks, "many experiments might be mentioned, all of which seem to show, more or less clearly, that the disposition to convulsive muscular contraction is inversely related to the supply of nervous influence to the muscles." Vide *Lancet*, 1863, Vol. I. p. 321. This is in the main correct, but it renders no support to the inhibitory theory of nervous action as propounded by its talented author. *The readiness with which the muscle contracts is always in direct proportion to the amount of force accumulated in its structure, or in other words, to its irritability.* It is not that the absence of nerve produces a greater proclivity to contraction in the muscle, but that the muscle in the absence of nerve can accumulate the force on which irritability depends. In all the experiments in which muscle contracts more readily in the absence of nerve the element *time* is an important ingredient, for if its influence be excluded the opposite condition, viz. *that muscle contracts more readily in the presence of nerve influence is the normal law,* as I hope shortly to show.

To the fact that muscle relieved from nerve influence acquires additional contractile energy, I add the further important observation, that it retains its irritability not unfrequently for days after its fellow has passed into the state of rigor mortis.

The experiment just cited also tends to show that the presence of nerve in action keeps down muscular irritability and induces earlier rigor mortis, as before demonstrated; for we see that when blood is

circulating equally through two limbs the irritability of the one cannot be maintained at the same standard in the presence of the nerve. If rigor mortis could be regarded as a contraction it might be supposed, in accordance with old notions, that the dying nervous system had something to do with its premature induction, but as rigor is a mere setting of the muscular tissue this idea has not a shadow of probability[1]; besides, the limbs will rigor simultaneously in cases in which the death of the animal succeeds immediately the section of the nerve.

Dr Brown Sequard has furnished us with a most beautiful experiment, which bears intimately upon the present question, and which also has been used by Dr Radcliffe to support the proposition "that the state of muscular relaxation is more readily disturbed by contraction, and that the contraction itself is more powerful when the muscles are receiving a diminished supply of nervous influence." The experiment is as follows, two frogs (A and B) are taken and their spinal cords divided low down in the cervical region, so as to remove the lower limbs from the control of the brain and medulla oblongata. In such cases the reflex (?) contractions induced by pinching the toes are capable of raising heavier weights than could be raised by the hind limbs when the frogs were in their normal condition. Thus they raised *before* division of the cord 60 grammes. Immediately *after* division A raised 20 and B 10 grammes only. In 5 minutes A raised 45 grammes and B only 30; thus they proceed increasing rapidly in power, till in four hours A can sustain 140 grammes and B 130; at the end of twenty-four hours they are found to have reached their maximum point, viz. 150 and 140 grammes respectively.

The first point worthy of notice in this important experiment is that a degree of shock was produced by the operation in frog A, measured by a loss of power equivalent to 40 grammes, and in frog B to 50 grammes. This diminished power would be entirely due to loss of nervous force and muscular irritability, chiefly the former, partly the direct result of severe injury to the nervous centres, and partly to loss of blood and depression of the heart's action.

Secondly, it would be at this period when A could raise but 20 and B 10 grammes only, while suffering from shock, that the *nervous influence would be at its lowest ebb,* and if the muscles possessed a fair amount of irritability, which they certainly do after such operations, this should be, if Dr Radcliffe's views are correct, *the period at which the greatest weights could be raised;* for the period of profoundest nervous shock admitting of neural excitement of the muscles would be the one in which the minimum degree of nervous influence exists.

[1] See my paper on this subject in the preceding Number of this *Journal*.

But it is evident that the muscular and nervous systems progressively acquire force from this shock-point, stopping not at their normal amount, but reaching a marvellously abnormal degree of exaltation, and this under the very conditions I have pointed out as leading to nervous and muscular exaltation, viz. the absence of the exhausting principle of volition or nerve in action.

We see then by these experiments that muscles possess no abnormal powers *immediately after* they are liberated from nerve influence, as in section of the sciatic, or after they are removed from the influence of the upper part of the cord, but that these *are gradually acquired,* many hours being consumed in reaching the maximum degree.

The correct explanation therefore of Sequard's experiment would seem to be, not that muscle contracts more readily in the absence of nervous influence, but that in the absence of volitional or other excitement both the nervous and muscular systems can accumulate their own special forces, and that to an extent that can never become apparent under normal life conditions. Thus in the experiment, 60 grammes measure the neuro-muscular force of the frogs when unmutilated. After the operation the frog B suffers more from shock, and the sum of its neuro-muscular force is represented in consequence by just half that of the other, or 1-6th of its normal force. A possesses after the operation 1-3rd of its normal force. The nervous system gradually recovers from the influence of shock, but is no longer stimulated by volition and therefore no longer controls the muscles in the usual way, consequently they remain flaccid or paralysed, and this gives them an opportunity of accumulating force, which they gradually do till they acquire nearly three times their normal amount. The exact proportions in which this accumulated force is divided between the nervous and muscular systems is a delicate subject for future consideration.

The fact is here broadly stated, that the psychical principle of volition dominates and exhausts both the nervous and muscular systems, and that in the absence of this influence they acquire exalted powers[1].

[1] In June, 1866, Professor Frankland read a paper to the Royal Institution of Great Britain, "On the source of muscular force," which contains the following passage: "The combustible food and oxygen coexist in the blood which courses through the muscle, *but when the muscle is at rest there is no chemical action between them.* A command is sent from the brain to the muscle, *the nervous agent determines oxidation.* The potential energy becomes active energy, one portion assuming the form of motion, another appearing as heat. *Here is the source of animal heat, here the origin of muscular power.* Like the piston and cylinder of a steam-engine the muscle itself is only a machine for the *transformation of heat into motion.*" The reader will at once perceive that this idea of muscular force being *generated only during nervous action* is quite incompatible with the experiments and views of the author of this paper. There can be no doubt that chemical action is constantly taking place between certain elements of

I propose now to turn for a short time to a consideration of the part which the blood plays in connection with muscular contraction. The following is the proposition which I shall endeavour to maintain.

That the blood or nutritional plasma derived therefrom not only furnishes the materials by which muscular contractility is maintained, but is likewise the determining cause of that polar arrangement of the muscular molecules which maintains or restores the elongated or relaxed state.

In the last No. of the *Journal* I drew attention to a form of muscular contraction induced in cold bloods by the irritant action of such vapours as æther, chloroform, bisulphuret of carbon, amylene, &c. I pointed out that they were the most extreme forms of contraction of which these muscles were capable. The persistent, in most cases permanent, character of the contraction at once associated it with the forms of tetanus induced by water of certain temperatures and by the discharge from Rhumkoff's coil. The extreme delicacy of this mode of exciting muscular contraction by ætherial vapours has enabled me to perform some very interesting and instructive experiments.

1. I have succeeded in proving by experiments in which the nervous system has, as far as possible, been removed, and better still, by experiments on isolated muscles, that both chloroform and warm water act *directly upon and produce universal contraction of the muscular tissue, which, according to the circumstances of its induction, may or may not be permanent.*

2. That when the nervous and vascular systems are present they complicate the result, and furnish us with illustrations of most important physiological principles.

Taking first THERMAL TETANUS, I find two normal limbs (i.e. supplied with both blood and nerve influence) contract simultaneously. Two limbs deprived of both blood and nerve influence also contract simultaneously. Two limbs, the one having neither nerve nor blood, and the other both nerve and blood, the latter contracts first. Two limbs, the one having neither nerve nor blood, and the other blood only, the former contracts first.

In CHLOROFORM TETANUS, the same holds good as in the first two examples of thermal tetanus; but in two limbs, the one having

muscle and blood, and *that force is being continuously stored*, nervous action being concerned in its consumption and discharge rather than in its formation. As to heat, it is certainly generated in other portions of the body besides the muscular structures, and if *nervous action* is necessary to oxidation, how is this heat produced?

The piston and cylinder is a means of regulating mere repellant force, but muscle is a mechanism having the power to convert some fluid, which is either electricity or a close correlate into a source of both repellant and attractive power; for it is only by assuming two such forces that the phenomena of elongation and contraction can be explained.

neither blood nor nerve and the other having both blood and nerve, the former contracts first. Two limbs, the one having neither blood nor nerve, and the other nerve but no blood, the latter contracts first.

An analysis of these various results shows that both warm water and chloroform exercise an excitant action upon the nervous system of the frog, which tends in both cases in the direction of muscular contraction, but which of itself alone is too weak to bring about such an affection of muscle, and further, that the warm water is more powerful in this respect than the chloroform. It also affords evidence of the important principle, that certain elements of the blood in the interstices of the muscular tissue oppose a powerful obstacle to such agencies as tend to throw muscular tissue into a state of contraction.

Muscle when dynamically perfect is related, on the one hand, to certain stimuli as nerve and external agents, which tend to induce contraction, and, on the other, to some of the elements of blood which bring about its elongation; but its degree of proneness to fall into contraction appears to be directly proportionate to the amount of force generated in it by the blood, in other words, to its irritability; and although the galvanometric evidences of the existence of force are *masked* during contraction by the derived electro-motor currents taking on the negative variation, yet this by no means proves (as some suppose) that the *blood-generated forces* are absent, for we have previously seen in explaining Sequard's experiment, that the contractive energy, i.e. the tendency of the molecules of muscles to approach each other, may be increased two and a half times, which is at once proof that they do not approach by virtue of any *permanent force* which they possess as mere physical atoms, for such force would be a fixed and not a varying quantity. It is evident, therefore, that both the power of contraction and of elongation is derived from the blood and not the elongating force alone, and we must not, with Dr Radcliffe, fall into the error of considering that muscle necessarily passes into a state of contraction in the absence of an elongating force; for experiment shows that the most perfectly relaxed state of muscle is compatible with the absence of every trace of irritability.

I shall now proceed to narrate several experiments in which the relation which blood bears to muscular tissue is more fully displayed, and by which it is made evident that the blood gives the power by which the elongated or relaxed state of muscle is maintained.

Exp. 1. A frog is moderately chloroformed; when removed from the vapour, particular note is made that the limbs are perfectly flaccid or relaxed, and that the heart is beating. The heart is now exposed and excised, and in a few seconds or minutes, according to the amount of chloroform imbibed by the tissues, *the limbs will spontaneously extend and become rigidly tetanic.*

Another frog was slightly chloroformed, and the observation made

that the heart was still acting, and that the whole of the muscles were quite flaccid. The structures of one thigh were then cut through to the bone, so as to sever all nervous and vascular connections. The muscles of this limb gradually commenced to contract, and in a few minutes the leg and foot were extended, and the webs stretched out. The muscles of the other limb and the trunk generally remained in a completely relaxed state. After the lapse of some minutes I observed a tendency in the unmutilated limb to extend, and in the forepaws to approach the central line of the body, and to clasp as in tetanus of the male frog. Directing my attention to the heart I could not detect any pulsation, and I therefore removed the parietes of the chest, the access of air re-excited the action of the heart, and very quickly the muscles of the unmutilated limb and general trunk became again flaccid. The heart again losing power, the condition of contraction a second time came on, and gradually became more and more complete. On re-examining this frog, after the lapse of an hour, I found that the muscles had again become flaccid; this time not only in the unmutilated limb, forepaws, and muscles of the trunk, but also in the limb which, as far as its soft parts were concerned, was completely amputated. Not the slightest trace of irritability was however now detectible. Nothing could be plainer than the teaching of this experiment. The muscular tissue was subjected to a dual influence; firstly, the chloroform tending to excite it to contract; secondly, the blood, or certain of its elements, tending to maintain it in the relaxed or elongated state; and accordingly as one or other of these influences prevailed, the muscles became alternately contracted or relaxed. After the cessation of the circulation, the antagonism was feebly continued between the evaporating traces of the chloroform, on the one hand, and the interstitial juices of the muscle, on the other, the balance of power being so nicely adjusted, that the interstitial nutrition was just capable of restoring the relaxed condition, but incapable of conferring the slightest degree of irritability upon the muscles. It is rarely that we obtain this exact balance of the influences; for if the amount of chloroform in the muscles is too large, the condition of permanent contraction obtains, and if too small, there are slight evidences of returning irritability after the muscle has become elongated.

Another satisfactory mode of exhibiting this function of the blood is to compress the abdominal aorta of a frog; and having ascertained by the microscope that the circulation in the lower limbs is securely arrested, oil all parts of the body, with the exception of one limb, expose this to the vapour of chloroform, protecting as much as possible all other portions of the body from its influence. This limb will, after a time, show a disposition to contract: it should then be

removed from the vapour, and when it has become fully extended, the torniquet should be taken off; the blood will then gradually find its way into the limb, and restore the flaccid elongated condition.

In this experiment we have the contrast of two limbs without blood, one of which is under a contracting influence; and we get an excess of chloroform in the tissues of one limb, and protect the animal to a great extent from being generally affected. As might be expected, this state of contraction is never so easy to produce when an animal possesses its full complement of blood; for although the blood may be stagnant in the vessels, it will supply for a considerable time the elements which oppose the contracting powers of the chloroform; hence if we would produce the state of contraction under such conditions, an amount of chloroform is demanded in the tissues which ordinarily destroys the animal; but by adopting the plan of allowing the ingress of the chloroform only through the limb which we wish to affect, we overcome this obstacle, and retain the heart in such a condition that the circulation can be restored and the contractive state dissipated, when the mechanical impediment is removed from the aorta.

In concluding this paper, I propose to take a hasty survey of the various affections of muscular tissue as they have presented themselves in my experiments.

Let us take as an illustration the gastrocnemius muscle of the frog in the elongated or uncontracted state.

1. It may exist in this elongated or uncontracted state with all its dynamical powers in a state of integrity. This is its normal condition as we see it in the absence of stimuli. 2. It may exist in this state when deprived of all dynamics; or, in other words, in the absence of irritability. 3. Both these conditions of elongation may be associated with softness or flaccidity of the muscular structure, the former necessarily so, the latter not as the fixity of rigor may prevail.

Now let us take the same muscle in a state of complete contraction. 1. It may exist in this state of contraction with its dynamical powers perfect. This is true in those normal contractions which quickly give place to relaxation. 2. It may exist in this state when deprived of all dynamics, as seen in the forms of permanent contraction induced by warm water and ætherial vapours. 3. In a state of softness, or in a hard coagulated state, the soft state is represented by normally contracted muscle severed from one of its attachments. The hard state is induced by ætherial vapours and extremes of temperature.

As with the state of elongation, so with that of contraction, the truly dynamical state is one of softness.

The dynamical conditions on which irritability depends may

therefore exist both in the elongated and in the contracted state, and may also be non-existent in both of these states. Properly speaking, irritability is no more the tendency which a muscle exhibits to contract, than the disposition it shows to relax or elongate subsequently to contraction, in fact, a comprehensive definition must include both these conditions; neither are either of these states to be considered (as far as muscle alone is concerned) as conditions of rest; for they are both active states so long as the muscle is a vital structure, and both inactive when the dynamics of muscle are absent.

As yet there seems to be no reliable experimental evidence to show that muscle *per se* ever contracts spontaneously, i.e. in the absence of a stimulus, but there are plenty of indications that the same agent is a greater stimulus at one time than another, nor is there any evidence to show that muscle will contract on the withdrawal of elongating influences, but abundance to the contrary, to the fact that it will remain in the elongated state in the absence of all susceptibility. Contraction and elongation would seem both to be dependent on the existence of polar forces which have a certain relation, on the one hand, to excited nerve and external stimuli, and, on the other, to some of the elements of the blood: excited nerve and external stimuli inducing the attractive which involves contraction, and the blood the repulsive polar attitude essential to elongation.

The attractive state of the muscular molecules which represents contraction, is the condition in which force is exhausted by the association of unlike polarities, while the state of elongation being that in which every molecule is opposed to every other, force may be accumulated. In proportion to the amount of force accumulated in the molecules will be the intensity of their contractive or elongative energy; and also in proportion to their charge will be their proclivity to disturbance, in other words, their susceptibility to stimuli.

When a stimulus can no longer act, it is because the force is exhausted. If the chemistry of the muscle be not absolutely arrested the power to contract under a stimulus will return. If at the moment of its action a stimulus be so excessive as to induce the attractive state of the molecules, and at the same time to destroy the force-producing powers of the muscle, the molecules will remain in the state of approximation, simply because there is an absence of any power to rearrange them. Conversely, if the force-producing powers be destroyed during the state of elongation, the molecules remain apart.

Muscle therefore, as a *dead structure*, has no tendency to remain in either one or other of these states preferentially. The loss of irritability is the first evidence we possess of a series of chemical changes which culminate in such a coagulation of the muscular

juices as to cause fixity or setting of the muscle. When these changes take place in the elongated muscle, the fixed condition is produced which we recognize as rigor mortis; when, on the other hand, they take place in the contracted muscle, they induce the fixed hard condition of the muscular structure seen in ætherial and thermal contractions.

Substances which affect muscular tissue may be classified as pure stimulants, stimulo-coagulants and depresso-coagulants. All substances possessing the coagulant property arrest the chemical reactions between the muscular tissue and the blood by which the fluid on which irritability depends is generated. The stimulo-coagulant class is represented by the irritant action of chloroform and the æthers generally and by extremes of temperature, the depresso-coagulant by chlorine, CO^2, and the sedative action of very dilute æther vapour.

It is possible therefore to have rigor mortis or coagulative setting in both elongated and contracted muscles.

While therefore my researches contradict the theory which refers the phenomena of living muscle to statical electricity *as an elongating power simply,* contraction being regarded as due to an inherent attractive power of the muscular molecules, they are singularly in accordance with the conclusions of Du Bois Reymond, who regards every elemental part of muscle as a centre of electro-motor action containing within itself positive and negative elements arranged in a dipolar series, and seem to fill up a gap by showing that the *repulsive attitude* of this series is *maintained by the blood.*

ON THE CONDITIONS OF THE PROTOPLASMIC MOVEMENTS IN THE EGGS OF OSSEOUS FISHES.

A Paper read at the Physiological Section of the British Association, Nottingham Meeting, 1866, *by* W. H. Ransom, M.D., *Nottingham.*

(Plate XI.)

The existence of certain movements, incorrectly described as rotations, in the egg of the pike, has been known to physiologists since the days of Rusconi. I first observed them in the yelk of two species of Gasterosteus in the summer of 1854, and proved their dependence upon contractions of a rhythmic character, in a Paper published in the *Proceedings of the Royal Society* in the autumn of that year. In the following spring I ascertained the essential similarity of the movements seen in the eggs of the pike, with those met with in the stickleback, and in a communication made to the Physiological Section of the British Association at the meeting held at Glasgow, in 1855, I explained the so-called rotations, describing them as oscillations, the effect of contractions.

Professor Reichert of Berlin, in Müller's *Archiv*, 1856, endeavoured to connect these movements with a peculiar structure, which he believed that he had discovered in the substance of the yelk of ripe impregnated eggs, but in the following year, 1857, he gave up this explanation, and referred the oscillations correctly to contractions of the yelk, although he still conceived them to be limited to impregnated ova.

The numerous observations which have recently been made, tending to shew the existence of a very widely diffused, if not constantly present, property of contractility in cell-contents or protoplasm[1], have

[1] Kœlliker, who was among the earliest observers of the facts upon which this generalisation has been based, suggested, in the third Edition of his *Handbuch der Gewebelehre*, the question, whether the contents of every animal cell did not, at some period or other of its development, exhibit spontaneous movements; and in the fourth Edition (1862) he considered that the question might be answered almost with certainty in the affirmative. In the same volume, p. 44, may be seen a useful but incomplete summary of the facts then known.

Hessling, *Grundzüge d. Gewebelehre des Menschen*, 1866, p. 25, gives a fuller epitome of the facts with historical references, and supports the general notion of contractility of protoplasm.

Frey, *Handbuch der Histologie*, &c. 1867, p. 87, collects and arranges the facts, and accepts the theory of a contractile property inherent in all protoplasm.

The monographs, by Max Schultze, *Das Protoplasma*, &c. 1863, and W. Kühne, *Untersuchungen ueber das Protoplasma*, 1864, added largely to the facts previously known, and supported the doctrines which the previous researches of E. Brücke, "Die Elementar Organismen. und Das Verhalten der Sog. Protoplasmaströme in den Brennhaaren von Urtica urens gegen die Schläge des Magnet-electromotors," in the *Sitzungsberichte d. Akad. der Wissen*, Wien, 1861—62, had, in conjunction with those of others, laid the foundation of viz. that the property of contractility was common to the protoplasm of all cells, animal and vegetable. Reichert has strongly dissented

induced me to make use of these eggs for experiments upon the essential conditions of its action, and on the modifying influences exerted by temperature, galvanism and poisonous substances: no other cells with which I am familiar presenting equal facilities for such an inquiry.

from this view, and has recently, *Archiv für Anatomie, Physiologie*, &c. 1866, p. 417, recorded his observations, and criticised severely the notion that the movements in cells of plants are due to contractions of the protoplasm.

C. Bernard, *Leçons sur les propriétés des Tissus Vivants*, p. 153, has added the weight of his name in favour of the notion, which appears generally held by the German physiologists, that all the contractile substances, including the striped muscular fibre, are but different grades of one and the same substance, and that all the various movements have but one single movement as their common essence.

The question what is this common essence? has not been answered, but attempts to trace by observation and experiment those properties which the various kinds of motor substance, met with in animals and vegetables, have in common, have of late been very numerous; as have been also observations tending to shew what are the resemblances and differences that exist between the protoplasmic movements as seen in the cells of higher animals and the vibrations of cilia and of spermatozoids; the movements of the soft substance of Rhizopods and other protozoa, as well as the cleavage of the yelk and multiplication of cells by fission. Some facts have also been given in support of the notion that the naked protoplasmic masses met with in the tissues are capable of changing their position, and travelling on to considerable distances.

Among the numerous workers in this field of research, besides those whose names have been mentioned, stand prominently forward Siebold, Wharton Jones, Lieberkühn, Huxley, Haeckel, Virchow, Remak, A. De Bary, Beale, Pflüger, Recklinghausen, Preger, Leuckhart, Lister, La Valette St George, and many others. So lively an interest indeed has this question aroused, that scarcely one of the German Journals devoted to Physiology now appears without containing one or more papers relating to it.

Dr Beale, among British physiologists, has done much to draw attention to the importance of the soft-cell contents, or protoplasm, to which he applies the term, in a restricted sense, 'germinal matter,' and has adopted views which would give to it, could they be proven, a still greater importance in the animal and vegetable economy than has been claimed for it by any other investigator. Not only does he claim for 'germinal matter' exclusively the possession of vital properties, but he says, "the contractility of muscle, the vibration of cilia, and the oscillations of the spermatozoa, are different in their nature from the movements observed in the white blood corpuscle, pus and mucous corpuscle, and in many of the lowest and most simple organisms, such as the amæba, the foraminifera, &c.......but with reference to the latter class of movements, it may be at once remarked that they cannot be accounted for by physics, nor are they to be explained by any chemical changes occurring in the matter itself." The *Physiological Anatomy and Physiology of Man*, 1866, p. 33.

But the experiments recorded by W. Kühne, and to these may be added those of which the results are here given, go far to shew that oxydation of the moving matter takes place in the protoplasm of the amæba as well as in the yelk of the egg during the existence of those movements, and that it is an essential condition of them.

This brief and imperfect reference to the literature of the question, to which the observations contained in this paper relate, will, it is hoped, add in some degree to their interest, and perhaps be of service to such physiologists as may not already have given special attention to the subject.

A reference to the figures 1, 2, 3, 4, will render a description of the normal contractions unnecessary.

POISONS. A series of experiments was made, to ascertain the effect of poisonous substances on the contractions of the yelk in impregnated eggs of stickleback, with the following results.

Dilute hydrocyanic acid, if very weak, did not in any perceptible degree alter the activity of the visible movements, but delayed the period of the commencement of cleavage. Stronger acid caused chemical changes of the substance of the yelk, and rupture of the inner sac. Atropia, aconite, and strychnia had also no visible effect on the movements. Carbonic acid rapidly arrested the contractions and effaced the sulcus present at the moment of its action, leaving the yelk-ball globular and relaxed. Very soon after, the germinal disc was retracted into the substance of the food-yelk, and then slowly reprotruded in an irregular form; after which it still more slowly became flattened, and the cleavage masses fused together into one formless mass (figs. 7, 8, 9, 10). Ultimately carbonic acid caused some chemical change in the matter of the formative and food-yelks, and rupture of the inner sac. The fusion of the cleavage masses took place before any evident chemical change appeared, and may be held to be evidence against the opinion entertained by some observers that they have a membranous covering. After the first relaxation of the contraction, and the effacing of the sulcus on the surface of the food-yelk, no further changes of its form were seen; and the method by which the retraction of the germinal mass and its subsequent protrusion took place, was not made out.

I continued this enquiry on the eggs of the pike, both impregnated and unimpregnated, which equally well exhibit the rhythmic contractions of the yelk. Solutions of acetate or hydrochlorate of morphia, and tincture of opium, had no effect on the movements, attributable to the narcotic constituents of opium, although slight indications of a retarding influence appeared, due to an excess of acetic acid in the first-named solution. Very weak solutions of ammonia did not influence the contraction; stronger solutions, (2 p. o.) caused rupture of the inner sac. Very weak solution of chromic acid had no effect. Weak alcoholic solution seemed to quicken the movements a little, certainly did not retard them. Tincture of cantharides acted similarly. Ether arrested the movements only when mixed by agitation with the water in sufficient proportion to cause opacity of the yelk. Chloroform applied in vapour rapidly arrested the rhythmic movements of the yelk, and then, after a time, fresh water being added, the contractions returned. This observation was made on eggs in which the embryo was somewhat advanced, and it was noticed that chloroform had a similar action upon the contractions of the striated muscles, and also on the movements of the heart,

which was then a mass of cell-like corpuscles. Weak solution of potash destroyed the movement by causing rupture of the inner sac without dissolving it afterwards. *Very weak* acetic acid made the contraction irregular, and interfered with the onward progress of the wave, but did not relax the yelk-ball or efface the sulcus; slightly stronger acid caused the yelk to coagulate.

The general indifference to poisonous agents shewn by this protoplasm may be due, in part, to the resistance presented by the inner sac to the passage of aqueous solutions; a fact shewn by other experiments.

GALVANISM.—To test the effect of galvanic excitation on the contractile substance of the eggs of the stickleback, I originally employed very weak primary currents, but without success. Either no effect was produced, or, with stronger currents, the yelk was decomposed without visible contraction being excited. By using weak, induced secondary currents, obtained from a machine capable of very nice graduation, different results were arrived at. Care was taken in these observations to bring the egg directly between the electrodes, touching them if possible, and appliances were used which enabled me to make and break contact without the slightest mechanical impulse being communicated to the cell, and without the necessity of removing the eye from the microscope.

Very weak currents applied for two or three seconds caused distinct peristaltic contractile waves, which were distinguishable from the normal ones by their greater depth, abruptness, rapidity of formation and progress, and by the unusual positions at which they began, as well as by the direction in which they travelled. Slightly stronger currents caused deep strongly-marked contractions, often followed, after a variable interval, by rupture of the inner sac, and more or less complete emptying of its contents. Repeated application of the current caused several such ruptures in the same yelk, and contracted the whole to a very small lobular solid mass, from which even the oil drops were squeezed out (see the figs. 5, 6). The excited contractions were found to begin near to either electrode, or distant from both, and the sulcus produced was either continuous with the line of the current, or at a variable angle to it. The waves had no constant relation to the axis of the egg. The weakest currents caused no electrolysis, and were slower in exciting the contractions. In all cases the tardiness of the reaction was such as to make it impossible to note any relation between the making or breaking contact and the commencement of contraction. Very strong currents were apt to cause prompt rupture with rapid contraction, near to one or other electrode, with electrolysis of the matter of the yelk. Ova, in the stages before the contractions naturally begin, or after they have ceased, were also excited to similar con-

tractions by similar currents. No part of the formative yelk or of the cleavage masses could be excited to visible contractions, but they were easily decomposed.

These experiments were repeated upon the eggs of the pike with a like result.

HEAT. I attempted to abstract heat and to restore the arrested contractions by galvanic currents. Some eggs in the stage of active contraction were cooled, until the thermometer placed on the cell stood at 32° F. They all became still and their yelks globular. They were not frozen; and I do not doubt that their temperature was higher than that indicated by the thermometer. They were then removed to the stage of the microscope and galvanized with the weakest currents, when very distinct contractions resulted. I had not, at that time, the means of maintaining objects on the stage of the microscope at any required temperature, and the eggs must have been continually receiving heat from the body of the instrument, while I was applying the galvanic current. This experiment is not, therefore, so conclusive as I could have wished; but, as very little time was lost in the operation, and as the eggs were cooled below the temperature at which they cease to move, I have little doubt that in this experiment the galvanic current excited contractions in eggs which would have been, but for the current, perfectly motionless.

In another observation I froze the water in which the eggs were placed, so that some of them were completely, and others incompletely frozen. The frozen eggs were all more or less opaque, and had their inner sacs ruptured, and emptied of yelk in various degrees, and their formative yelks lobulated and darkly granular. Those which were least frozen were slightly opalescent only, and when allowed to thaw, they contracted as before; ultimately, going on to cleave in an irregular manner; the ruptures in their inner sacs having healed. Slighter reductions of temperature to 40°, 48° F., retarded without destroying the contractions. In such cases the commencement of cleavage was delayed. By raising the temperature moderately, the movements were accelerated; but at about 80° F. (it is difficult to speak with certainty of the temperature actually attained by the object) the contractions were arrested; the yelk-ball becoming globular, and the oil-globules being scattered. Such eggs, however, soon recovered themselves when left at 58° F., and cleft in even less time than eggs did which had not been warmed. In other eggs heated in a chamber at 102° F. the cleavage was retarded to three times the usual period, and when it took place was wanting in symmetry. The yelk began to become opalescent at about 103° F.; but a true coagulation of the albumen did not take place, the yelk being fluid, end opaque.

Thus a temperature too low, or too much elevated, retards or

arrests the contractions; but they are not destroyed before commencing physical and chemical changes set in.

INFLUENCE OF OXYGEN IN THE SURROUNDING MEDIUM ON THE YELK CONTRACTIONS.—I attempted to solve this question by placing eggs of the stickleback, while actively contracting, in closed cells in water deprived of oxygen as far as possible; and comparing the further progress of such eggs with others in similar cells in oxygenated water, and with others in open vessels. I used cells of the same dimensions, the same number of ova, and the same mode of sealing the cover in all the experiments, and found that the rhythmic yelk contractions and the cleavage went on just the same in aërated water, in boiled water, in boiled water saturated with hydrogen, and in water saturated with oxygen, during twenty hours; after which time the observations were not continued. While using $\frac{1}{6}$th the number of recently hatched embryos in the same cells similarly sealed, I found the trunk of the embryo ceased to move in 10 minutes, and the heart in 70 minutes, in boiled water; and in water boiled and saturated with hydrogen, the heart ceased in 55 minutes.

So that it would seem, judging from these observations alone, that the rhythmic contractions and the cleavage are independent of the presence of oxygen in the surrounding medium. But as the method adopted did not exclude oxygen completely, and as the period during which the observations were continued was short, this conclusion is not warranted; and it is more correct to say that the rhythmic contractions and the cleavage consume proportionally much less oxygen than striated muscle or cellular contractile tissue.

I pursued this question further in the Spring of the present year, using the eggs of the pike, which are better adapted for the purpose, being obtainable in greater numbers, and shewing the rhythmic contractions as well in the unimpregnated as in the impregnated state; thus enabling me to make experiments, separating the question of the cleavage movements from that of the yelk contractions.

Being unable to procure water absolutely free from oxygen, (which is well known to be a difficult thing to effect, and to require prolonged ebullition in vacuo), I boiled distilled water with pounded glass until the bumping became dangerous to the containing vessel, and poured pure olive oil on the boiling surface; hoping by this means to drive off the oxygen sufficiently, so as to render the water irrespirable.

By a simple contrivance I passed ova from the fish into the boiled water defended with oil, without previous contact with any oxygen carrier. As the boiled water, however, still contained some oxygen, I endeavoured to meet the difficulty by employing varying proportions of eggs to water, in order to note the relative duration of the contractions.

Four experiments were made with unimpregnated eggs, using 1 to 10, 1 to 3, 1 to 1, and 2 to 1 parts of ova to the water; but as it was found that only some of the eggs, viz. those which formed the surface layer, imbibed water and expanded, so as to permit freedom of movement for the yelk-ball, no certain conclusion could be drawn from the proportional duration of the contractions. In the first three experiments the eggs of the upper layer continued to shew the rhythmic contractions for seventy-six hours, while those in the fourth experiment did not distinctly contract in consequence of the deficient supply of water. Compared however with eggs which, for the sake of control, were kept at the same time in an abundant supply of aërated water changed daily, a distinct result was obtained; as these continued to contract for 100 hours at least. Concurrently with the rhythmic yelk-contractions some changes of form took place in the formative yelk; that is, it concentrated as in impregnated eggs, and then became irregularly lobulated and divided on the surface into separate masses, which often became detached, terminating at length in a complete separation of the whole proligerous disc. This 'pseudo cleavage,' as it may be called, as well as the rhythmic contractions, was impeded in eggs in which the supply of water was deficient, and was seen to be most active in the eggs kept in aërated water.

I may mention here that it is to this fissile contractility of the formative yelk that the formation of the so-called "Richtungs-Blaschen" seems to me to be attributable.

A similar series of experiments was then attempted with impregnated eggs; but they failed in consequence of the difficulty of conveying the milt through the layer of oil.

I therefore made a series of suffocative experiments on impregnated and unimpregnated eggs, using aërated distilled water in cells, all of the capacity of ·05 cubic inch, sealing the covers with hot wax, and varying the number of eggs in each cell.

Five observations were made with unimpregnated eggs, having respectively 35, 30, 18, 9, and 7 eggs in a cell; and although, in consequence of the accidental loosening of the wax and the entrance of a little bubble of air, the duration of the contractions was not in all cases inversely as the numbers of ova in the cells, yet the general result was that both the rhythmic contractions and the pseudo cleavage continued longer in the cells containing the smaller number of ova; the eggs which lay nearest to the air-bubble always being the last to cease to move. The accidental failure of the luting affording thus additional evidence of the importance of oxygen. In all the cells the contractions ceased in from 23 to 30 hours, or one-fourth of the time they continued in aërated water and unlimited space. Five similar observations were made on impregnated eggs with 48, 38, 17, 10, and 7 eggs in each cell; with similar but more marked results;

the yelk contractions ceasing earlier than in the unimpregnated ova. The cleavage was more rapidly checked than the pseudo cleavage, and still more so than the yelk contractions. Thus, in the experiments with 48 and 38 eggs in the cell, the germinal disc did not cleave into more than 16 masses, a stage which corresponds to the 7th or 8th hour after impregnation; while, in the experiments with 10 and 7 eggs in the cell, the cleavage went on to the mulberry stage before it was arrested.

It is interesting and instructive here to note, that the cleavage masses, soon after the arrest of the process, commenced to undergo fusion, and presented an appearance of increased granularity and relaxation of the yelk-ball, very similar to the effects before mentioned as following the action of carbonic acid.

Experiments were made to detect in the water in which eggs had been contracting and cleaving some product of oxydation, but without any satisfactory result. However, it was made out that an organic colloid passes into the water, and with it chlorides and phosphates, the latter in an extremely minute proportion. I could find no chemical evidence of carbonic acid.

Seven experiments were then made to ascertain the relative dependence upon the presence of oxygen of the movements which result in cell-multiplication and differentiation, and of the muscular contractions of the embryo compared with the yelk contractions.

Two healthy developing ova were sealed in similar cells at 76, 101, 127, 150, and 174 hours each, after impregnation, and two free embryos at 24 and 48 hours after hatching. Although the proportion of active organic matter to the medium was so very much less than in the previous experiments, with recently impregnated eggs, yet the process of development ceased in all in about 7 hours, and the yelk-contractions did not continue more than 18 hours. The movements of the heart continued about the same time; those of the trunk ceasing before the heart. The embryos in the later stages of development more quickly ceased to move than those in the earlier.

The inference is, I think, not to be resisted, that oxygen in the surrounding medium is an essential condition of the exercise of the property of rhythmic contractility possessed by the food-yelk, as well as of the fissile contractility of the formative yelk. But the quantity of oxygen consumed in these actions appears to be extremely minute: is less in the rhythmic than in the fissile contractions, whether before or immediately after impregnation: less in both than in the cell-multiplication and differentiation going on in the later stages of embryonic growth, or during the action of striated muscle. It was not so certainly made out that the cellular heart consumed more oxygen than the food-yelk, but its position is exceptional in relation to its own medium, which it tends ever to renew.

The dependence upon oxygen of the fissile contractions which result in cell-multiplication seems to be even more immediate than are the contractions of voluntary muscle, and the production of some product of oxydation which acts poisonously upon the contractions of the food-yelk, much in the manner of carbonic acid, is pointed to distinctly by the early cessation of those movements when in the presence of a small amount of growing tissue in a confined space.

To this faculty possessed by the yelk of continuing its activity in a medium nearly deprived of oxygen is probably due the persistence of the rhythmic movements, in the midst of surrounding decomposition, a fact which was often noticed with some surprise.

EXPLANATION OF THE FIGURES.

N.B. All the Figures are taken from actual objects, but are diagrammatic.

Figure 1. Ovum of Gasterosteus about 20 minutes after impregnation, just before the rhythmic contractions begin.

- *a.* The dotted yelk sac.
- *b.* The micropyle, surrounded by button-shaped processes.
- *c.* Food-yelk.
- *d.* Oil drops.
- *e.* Firmer surface of food-yelk or inner sac.
- *f.* Breathing chamber or space between the yelk and yelk-sac, filled with water.
- *g.* The formative yelk concentrated at the germinal pole, and called in impregnated ova, 'germinal disc.'

Figure 2. Commencement of normal contractions, a sulcus beginning at one side.

Figure 3. The sulcus extended all around, causing the dumb-bell form.

Figure 4. The wave has travelled towards the germinal pole, and produced the flask-shaped form.

Figure 5. Commencement of a contraction excited by a feeble galvanic current.

Figure 6. Two contractions present at once, and travelling at right angles to the normal ones. Excited by weak galvanic currents.

Figure 7. An impregnated ovum just after the first cleft is completed, to shew the normal aspect.

Figure 8. The same a few minutes after the action of carbonic acid. The germinal disc retracted.

Figure 9. The same a little later. The germinal disc protruded, irregular in form.

Figure 10. The same after a longer action of carbonic acid. Shewing complete relaxation of the yelk-ball and fusion of the cleavage masses.

On the MUSCULUS STERNALIS. By Wm. Turner, M.B. (Lond.) F.R.C.S.E., F.R.S.E.

(Plate XII.)

Anatomists have noticed the occasional occurrence in the human body of a muscle situated on the anterior aspect of the thorax, superficial to the great pectoral muscle. By various writers it has been called 'musculus sternalis,' or 'presternalis,' or 'rectus sternalis,' or 'sternalis brutorum,' or 'thoracicus.' For several years I had seen occasional specimens of this muscle without keeping any record of their arrangement; but since the year 1858 I have preserved in my note-book a description, and had drawings made of the different examples which have occurred in the subjects received for dissection in the anatomical rooms of the University of Edinburgh. In this communication I intend to give an account of the variations in form and arrangement which they assumed, and to conclude with some remarks on the history of the muscle, and the opinions entertained respecting its morphology, which possess features of interest to the anatomist.

The muscle was found in 21 of the 650 subjects dissected during the period over which the observations extended—that is, in about three per cent.—of these 7 were males, and 11 were females; but as in 3 the sex was not noted, the proportion may be nearly equal in the two sexes. Some were the bodies of powerful males, whilst in others the muscular system generally was but feebly developed, so that no direct relation existed between its presence and the general muscularity of the individual. In 12 subjects the muscle was single, in 9 double, so that the number of specimens of the muscle amounted to 30.

It varied in its inferior attachment (origin) in different individuals. In 12, Figs. 3, 4, 5, it was connected to the flattened tendon of the external oblique muscle of the abdomen, opposite the 5th and the 6th costal cartilages, where it formed the sheath of the rectus[1], and in one of these it had an additional attachment to the side of the sternum close to the articulation of the 4th costal cartilage: in 6, to the cartilages of the 5th and 6th ribs, close to the insertion of the rectus abdominis, Fig. 6, and in one of these it arose, in part, from the bony portion of the 6th rib, just outside the cartilage, Fig. 2: in one, to the cartilage of the 7th rib, close to the attachment of the pectoralis major: in one, to the decussating fibres in front of the

[1] As the flattened tendon of the external oblique (aponeurosis as it is commonly called) consists not only of the proper fibres of the tendon of the muscle, but of the muscular sheath, the two being so intimately blended that no separation can be effected, it may be a question for consideration whether this origin of the sternalis ought not rather to be referred to the latter than to the former.

lower end of the sternum and ziphoid cartilage: in one, whilst its origin was in great part derived from the flattened tendon of the external oblique, it possessed, in addition, attachments to the cartilages of the 5th and 6th ribs, close to their sternal ends.

The muscle also varied in its superior attachment (insertion). In 3 individuals its tendon was connected to the anterior surface of the manubrium sterni. In 8 it ended in and became continuous with the sternal heads of origin of one or both sterno-mastoid muscles, Figs. 4, 5, 6. In 2 it blended with the upper sternal fibres of the great pectoral close to their origin, Fig. 1. In 4 it ended partly in the sternal origin of the sterno-mastoid, and, partly, in front either of the manubrium or body of the sternum, Fig. 5: in one, partly in the substance of the left great pectoral opposite the second rib, partly in front of the manubrium, and partly in the left sterno-mastoid: in one it was attached both to the front of the manubrium, and to the fibres of the great pectoral opposite the second and third costal cartilages: in one—a single muscle—whilst its inner fibres joined by two rounded tendons the sternal tendon of the right sterno-mastoid, sending an offshoot to the manubrium, its outer fibres ended superficially in the upper part of the pectoral aponeurosis: and in another individual—a double muscle—the upper tendon on each side blended altogether with the aponeurosis covering the sternal and clavicular fibres of the pectoralis major, Fig. 3.

As a rule the belly of each muscle was flat and ribbon-shaped; but many variations in length, breadth, and thickness, were met with. The broadest specimen was $1\frac{1}{2}$ inch at its widest part, but tapered off, more especially towards the upper extremity. The narrowest specimen was only $\frac{1}{5}$th of an inch in its greatest transverse breadth. The tendon of origin was usually flat and expanded, more especially in those cases in which it arose from the sheath of the rectus. The tendon of insertion was usually rounded and slender. In most of the specimens the muscle was undivided; but in one it was slit up into two distinct bundles, and in 3 into three bundles. In those specimens in which the muscle had more than one origin the digitations remained distinct for a short distance before they united to form the fleshy belly.

In the 12 individuals in whom it occurred as a single muscle it was situated five times on the right side, twice on the left, whilst in the remaining five it arose on one side of the middle line, and then either crossed in front of the sternum to be inserted altogether on the opposite side, or was in part inserted on the side of origin, in part by fibres crossing to the opposite side in front of the middle line.

In all the bodies in which the muscle was double, the expanded origins were distinct and separated from each other by the sternum;

and in 3 the muscles pursued an independent course on each side to their insertion, whereas in 6 the tendons of insertion of each pair of muscles, sometimes expanded, sometimes rounded, blended with each other opposite the manubrium, and in all the specimens, with two exceptions, they became continuous with the sternal origins of both sterno-mastoids. Usually the muscles on opposite sides of the same subjects were nearly equal in size, Figs. 3, 6; but in one case a considerable disparity existed, the right muscle being broad and well marked, and the left little more than a single fasciculus, Fig. 4.

In the specimen in which the muscle arose from the 5th and 6th left costal cartilage and the osseous part of the 6th rib, it pierced the great pectoral muscle on its way to the surface, Fig. 2. In two specimens some muscular fibres left the sternalis, and joined the great pectoral close to its sternal origin. The extent to which the great pectoral muscle derived fibres of origin from the sternum varied very materially in the different subjects. In one, in which the sternalis was unilateral, the fasciculi of the two greater pectorals interdigitated in front of the sternum, Fig. 1: in one in which the sternalis was bilateral they scarcely reached the side of the sternum: in another, also with a bilateral sternalis, the pectorals only received sternal fibres of origin from the manubrium, and the cartilages of the true ribs below the first were uncovered by any muscle except the sternalis, Fig. 6.

The relations of the muscle to the sternum varied in the different specimens. In the greater number it was situated either altogether, or in part, in front of that bone, and was either in contact with, or separated from it, by the fibres of origin of the greater pectorals. In a few cases it was placed, superficial to the pectoralis major, a little distance on one side of the sternum for the greater part of its extent, though in its course upwards it usually inclined inwards in front of that bone.

The greater number of anatomists who have given an account of this muscle have done so from a single, or a limited number of specimens, so that their descriptions, although perfectly accurate for the examples they had met with, have not sufficiently brought out either the variability which the muscle exhibits in its arrangement, or the comparative frequency of its occurrence. The special observations which I have made during the last eight years on more than six hundred individuals show that we may find this muscle present, in one or other of its forms, in at least three per cent. of the inhabitants of this country, so that we may always expect to see it in our dissecting rooms with a certain measure of regularity and frequency[1].

[1] Prof. Wenzel Gruber (*Mém. de l'Acad. Imp. de St Pétersbourg*, Tome III. 1860), who examined 95 subjects, with the especial object of determining the frequency of occurrence of this and other supernumerary muscles, found it present in 5, three times

The great variability, both in the size and connections of the muscle and its not unfrequent want of symmetry, bear out the truth of the general statement, that occasional structures are especially liable to variations in arrangement, and indicate that it is a rudimentary structure; and it is obvious that it can have but little physiological value in the movements of the thoracic wall.

History. Cabrolius (*Anatomes elenchus accuratissimus,* Obs. 8, p. 96) in 1604 seems to have been the first anatomist who observed a longitudinal band-like muscle, situated beneath the skin and fat, superficial to the sternum, but the relations and connections of the sternalis muscle were not precisely described until 1726, when Du Puy (*Histoire de l'Acad. Royale des Sciences,* Amsterdam) gave an account of a well-marked example, which he had met with in its bilateral form. Shortly afterwards other specimens were observed by Weitbrecht (*Comment. Acad. Petropolitanæ,* 1729, Vol. 4, p. 258), Albinus (*Historia Musculorum,* 1734, p. 291), De la Faye (*Histoire de l'Acad. Roy. des Sciences,* 1736, p. 82), and Wilde (*Com. Acad. Petropol.* Vol. 12, 1740, p. 320). In 1751 an important memoir on the subject by Kaau Boerhaave (*Idem.* 1751, p. 257) appeared, in which he not only gave an elaborate account of two very fine specimens, which he had seen, but also described a case where the right rectus abdominis ascended beneath the pectoralis major as high as the third costal cartilage and rib. Basing his account of the muscle on Boerhaave's description and figures, Sandifort (*Exercitationes Academicæ,* 1783, p. 82) called it Thoracicus, a name which has frequently been applied to it by subsequent writers.

Portal (Letter from M. Juppin in *Journal de Médecine, Chirurgie et Pharmacie,* April, 1773, Vol. 39, p. 309, and *Cours d'Anatomie Médicale,* Vol. 2, 1803) considered that the occasional existence of this muscle might serve to throw some light on a subject which at one time had excited much discussion amongst anatomists. Those who have directed attention to the history of anatomy will remember that a most keenly debated question was, whether Galen had derived his knowledge of anatomy from the dissection of human bodies, or of those of the mammalia, more especially dogs and monkeys. Vesalius (*de Humani Corporis fabricâ*) in his great work on human anatomy supports the latter view, and adduces, as one of the arguments in favour of his opinion, that Galen described the rectus abdominis as extending to the upper part of the chest, which is the case in many of the mammalia, though not in man, and he even gives a figure (Plate v.) in illustration of Galen's description, in which he superadds to the human rectus that part, which, deficient in man, occurs in certain mammals. Portal and other modern defenders of Galen think that the human body, or bodies, he may have examined might have possessed a sternalis muscle in a well-marked form, which would therefore have afforded some reason for such a description of the rectus as Galen has given.

Very different opinions have been held by anatomists of the morphology of the sternalis muscle. By far the greater number hold that it is an upward prolongation of the rectus abdominis, though others regard it as a downward extension of the sterno-mastoid; others, as an offshoot of the panniculus carnosus, and the most recent writer on the subject considers

on both sides, once on the right side, and once on the left. The percentage stated in the text, being drawn from the examination of a larger number of individuals, probably gives a more correct average.

that it is a muscle *sui generis*. It may not be without interest if we discuss those different opinions more in detail.

Albinus seems to have been the first to indicate that this muscle was to be regarded as connected with the rectus, and this conception of its anatomical position was strongly advocated by Portal. Sömmering (*De Corp. Humani Fabricâ*, Vol. 3, 1796, p. 150), Sabatier (*Traité d'Anatomie*, 1798, Vol. 1, p. 353), Ganzer (*Dissertatio Anatomica musculorum varietates*, Berlin, 1813), Otto (*Seltene Beobachtungen*, 1816, p. 90), Meckel (*Handbuch der menschlichen Anatomie*, Vol. 2, p. 465), M'Whinnie (*Medical Gazette*, 1846), Budge (*Henle und Pfeuffers Zeitschrift*, Vol. 7, 1859, p. 276), and the Editors of Quain's *Anatomy* (7th edition, London, 1864, p. 243), all coincide in this view, and consequently apply to the muscle the name of rectus sternalis, or sternalis brutorum.

But the connection of the sternalis muscle with the rectus abdominis, and its consequent homology with the anterior or pectoral end of the rectus, found in so many mammalia, seems to me to be more apparent than real. In none of the twenty-one subjects in which I found this muscle were its fibres directly continuous with the rectus, and in this respect my observations generally agree with those of preceding writers[1]. In a few cases indeed it arose from the cartilages of the lower true ribs into which the rectus was inserted; but in the greater number it took its origin from the flattened tendon of the external oblique muscle of the abdomen, i. e. from a plane superficial to the rectus. Again, in none of my specimens were transverse tendinous intersections present, such as are so characteristic of the abdominal recti, and in the greater number of the recorded cases no mention of such structures is made. Portal and Hallett[2] have, however, each seen a case in which they existed, and Meckel states that they are occasionally present. But a yet stronger argument against the theory that it is an upward extension of the rectus is derived from its position. For in all those mammals in which the rectus is prolonged far forward on the pectoral region, its anterior fibres lie deeper than the great pectoral muscle and in contact with the ribs, whilst the sternalis in man as constantly lies on the superficial aspect of the pectoralis major. Again, a muscle has occasionally been seen in the human body, which, differing in its position from the sternalis, is undoubtedly to be regarded as homologous with the anterior fibres of the rectus. Boerhaave first described this muscle, which was directly continuous with the upper fibres of the right rectus, and was prolonged upwards behind the greater pectoral muscle as far as the junction of the bony and cartilaginous parts of the third rib. Portal would also seem to have seen two or three times a muscle continuous

[1] Bourienne, *Journal de Médecine, Chirurgie, et Pharmacie*, January 1773, Vol. 39, p. 45, is the only anatomist who has described the fibres of the rectus and sternalis as blending with each other, and as his case is amongst the earliest specimens recorded, the dissection may not have been made with critical exactness.

[2] *Edinburgh Medical and Surgical Journal*, Vol. 69, p. 11, 1848.

with the rectus extending as high as the second rib[1]. This muscle has by some writers been confounded with the sternalis; but it is obviously quite distinct from it, and may, as Halbertsma[2] has indeed suggested, very appropriately be named musculus accessorius ad rectum.

Bourienne (*op. cit.*) many years ago contended that the sternalis muscle is a prolongation downwards of the sterno-mastoid, and both Theile[3] and Henle[4] are evidently of the same opinion. Undoubtedly the sternalis at its upper end is not unfrequently continuous with the sternal tendon of origin of that muscle. In thirteen of my twenty-one cases it was, more or less, completely blended with it, and similar results have been obtained by other anatomists. In many mammals also the attachments of the sterno-mastoids are continued backwards for some distance on the front of the sternum superficial to the great pectoral muscles. In the armadillo, the beaver, and the echidna, this arrangement is very well marked; but I am not aware of any mammal in which they reach the flattened tendon of the external oblique, or become continuous with the rectus abdominis. For in those animals in which the sterno-mastoids are prolonged backwards, superficial to the great pectoral muscles, the recti are also continued forwards, but in relation to their deeper aspects, so that these muscles are separated from each other by the thickness of the greater pectoralis. Hence the opinion entertained by Meckel, that the sternalis was an animal form which connected together the sterno-mastoids and recti, and which gave to the muscles of the ventral surface a longitudinal arrangement uniform with those on its dorsal aspect, is not supported by comparative anatomy[5].

Wilde (*op. cit.*), in the remarks which he makes on a specimen of the sternalis muscle, states that it is difficult to say whether it is to be referred to the platysma myoides or represents another muscle; and Hallett (*op. cit.* p. 28) observes, that if it is traced through its various grades of size, it will be seen to belong to the same class of muscles as the platysma, and is consequently a development of the great skin muscle. Many arguments may be advanced in favour of this conception of the morphology of the muscle. Thus it is well

[1] I think that the muscle figured by Mr John Wood (*Proc. Roy. Soc. London*, June 15, 1865, Fig. 1 *d*), and described by him as a supra-costal muscle, is, from its position and the direction of its fibres, probably to be regarded as homologous with the pectoral end of the mammalian rectus, though it must be admitted that it is not continuous with the abdominal part of the muscle.

[2] *Musculus Thoracicus, Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen*, p. 164, 1861, Amsterdam.

[3] *Traité de Myologie*, p. 185, 1843.

[4] *Muskellehre*, p. 95, 1858.

[5] In the frog in which the abdominal recti are prolonged far forward these muscles become continuous with the sterno-hyoids, but not with the sterno-mastoid muscles.

known that the platysma in man may be traced downwards over the clavicle; and in muscular subjects I have not unfrequently seen it descend for three or four inches superficial to the fibres of the pectoralis major. Again, though the platysma and palmaris brevis are by many considered to be the only representatives in man of the great panniculus of most mammalia, yet one occasionally finds in other parts of the human body isolated and somewhat fragmentary rudiments, and in the note below several examples which I have met with are described[1]. Teichmann[2] also has seen a case (of especial interest in connection with those specimens of the sternalis which pass superficial to the sternum from one side to the other), in which the human platysma crossed in front of the sternum, decussating with its fellow, and descended to the third costal cartilage of the opposite side. The variations in connection and size which the sternalis muscle exhibits also show its affinities to the great skin muscle of the mammalia, and in the occasional attachment of one end of the muscle at a deeper plane than the other, especially where the more superficial tendon is blended with the aponeurosis of the pectoralis major, it presents another point of resemblance. Again, in those mammalia which possess great mobility of the skin, such as the

[1] Without taking into consideration the muscles of expression, the extrinsic and intrinsic muscles of the auricle and the occipito frontalis, all of which act on the integument, and may therefore fairly be enumerated amongst the cutaneous muscles, I may direct attention to the following rudimentary muscles, which I have found in the human body, and which from their superficial position are evidently to be referred to the panniculus carnosus.

1st. Anatomists are well acquainted with the occasional presence of a musculo-tendinous band proceeding from the latissimus dorsi, and crossing in front of the axillary vessels and nerves, to end either in the aponeurosis of the arm covering the upper part of the coraco-brachialis muscle, or in the insertion tendon of the great pectoral. This additional structure has not unfrequently associated with it thin and perhaps scattered muscular fasciculi, which arise from the fasciæ in the neighbourhood of the axilla. In a male subject I saw on both sides well-marked red fasciculi arise from the pectoral aponeurosis, turn round the axillary border of the pectoralis major, and become continuous with the additional slip from the latissimus. In another male subject the additional slip on the right side received a number of scattered muscular fasciculi, which arose from the superficial aspect of the fascia covering the serratus magnus, and along with these were other fasciculi, which were attached to the fascia forming the floor of the axilla.

2nd. On both sides of a female subject a thin layer of muscular fibres arose superficial to the fascia covering the infra-spinatus muscle, close to the posterior border of the scapula, and joined the lower margin of the trapezius near to the spine of the scapula.

3rd. On the left side of a male subject a thin muscle half an inch broad arose from the fascia over the acromion: it passed backwards and ended in the trapezius opposite the spine of the first dorsal vertebra.

4th. On both sides of a female subject muscular fibres arose superficial to the aponeurosis covering the glutæus medius. The origin was broad and extended downwards towards the ilio-tibial band of the fascia lata. The fibres ascended, crossed over the iliac crest, and blended with the external oblique muscle of the abdomen.

[2] Henle, *Muskellehre*, p. 108.

hedge-hog and the echidna, the panniculus is not only well developed on the dorsal and lateral, but also on the ventral surface of the body. In arctomys alpina, mus decumanus and mus campensis[1], a well marked process of the panniculus passes backwards on the superficial aspect of the pectoralis major, and approximates therefore in its arrangement to the sternalis.

The late Professor Halbertsma (*op. cit.*), the most recent writer who has discussed the position of the sternalis muscle, regarded it as a muscle *sui generis*—one peculiar to man and having no animal representative. Undoubtedly there is no animal in which a muscle exists possessing such connections as the largest and best marked forms of the sternalis exhibit; but for the reasons which have been just given, I am inclined to think that it approaches so closely in many of its characters to the panniculosus carnosus, that it may perhaps be regarded as an additional rudiment in man of that very important tegumentary muscle, though it must be admitted that the human platysma lies on a plane superficial to the fibres of the sternalis in those individuals in whom they co-exist.

[1] Cuvier and Laurillard, *Myologie Comp.* Pl. 209, e.s.

EXPLANATION OF PLATE XII.

Fig. 1. A slender right sternalis muscle arising from the decussating tendinous fibres in front of the lower end of the sternum, inserted into the front of the manubrium and joining by a rounded slip the upper fibres of the pectoralis major.

Fig. 2. A sternalis muscle arising from 5th and 6th left costal cartilages and 6th rib. It passed obliquely upwards and inwards across the front of the sternum to be inserted into the strong fibrous aponeurosis over the right pectoralis major, opposite the 2nd right costal cartilage.

Fig. 3. Double sternalis muscle arising from 5th and 6th costal cartilages inserted into aponeurosis covering greater pectoral muscles.

Fig. 4. Double sternalis, right much larger than left, extended from aponeurosis covering rectus to right sterno-mastoid, whilst left was inserted into aponeurosis covering manubrium sterni.

Fig. 5. Right sternalis muscle arising from aponeurosis covering rectus, subdivided into various bundles, the external of which ascended to the sterno-mastoid, the internal into manubrium close to sternal fibres of origin of left pectoralis major.

Fig. 6. Double sternalis arising from cartilages of 5th and 6th ribs, inserted mostly into tendons of two sterno-mastoids, some fibres from the left muscle were attached to the manubrium sterni. Sternal origins of both greater pectoral muscles very defective.

ON SOME POINTS IN THE ANATOMY OF THE CHIMPANZEE. By PROFESSOR HUMPHRY, F.R.S.

(PLATE XIII.)

THE following observations, intended as an addition to the large amount of information we already derive respecting this animal from the researches of other anatomists, are the result of opportunities lately afforded me of dissecting a male and a female Chimpanzee which died in the Zoological Gardens, Regent's Park. They refer chiefly to the differences in the hinder or lower limbs from the corresponding parts in man[1].

In the HIP-JOINT, the only points of importance that I observed were, *First,* that the acetabulum was rather shallow, and the cotyloid ligament did not embrace so much of the head of the femur as in man. *Secondly,* the head of the femur formed a smaller part of a sphere, and it overhung, in a marked manner, or projected in front of, the fore part of the neck, which was much constricted near the head. This feature is common in quadrumana. Whereas, in man, the fore part of the neck of the femur is comparatively thicker, and, in front, is broad, and nearly on a level with the articular surface of the head on the one side, and the trochanter on the other. This difference—this strengthening of the fore part of the neck of the femur in man—has relation to the mode in which the weight is received upon it as the body is carried forwards in walking. The relative length of the neck and the angle it forms with the shaft are about the same as in man. *Thirdly,* the anterior 'intertrochanteric line' was scarcely distinguishable. The presence of this as a bold, rough line, descending from the fore part of the great trochanter, in front of the lesser trochanter, seems to be almost peculiar to man. It gives attachment to the strong anterior ligament of the hip (the thickest and strongest ligamentous mass in the human body) which becomes tense in the extended or erect position, and which, by preventing the pelvis and trunk from rolling backwards upon the thigh, contributes so much security and ease to that position; see my treatise on the Skeleton, p. 514.

The round ligament was strong. It is curious that this ligament should be absent in the Orang, though present in most other Apes. I judged, though I could not be sure of this, that it came into play, as it does in man (see my treatise on the Human Skeleton, p. 519), in the slightly bent position of the joint. The disposition of the muscles about the hip was much as in man.

[1] Both the animals were young, that is to say, the epiphyses were not ankylosed in either. The female was $25\frac{1}{2}$ inches long and weighed 8 lbs. $2\frac{1}{2}$ oz. The male was 36 inches long; it was skinned when it arrived. The descriptions are chiefly taken from the latter, those of the joints, the larynx, tongue, and bladder, exclusively so.

In the KNEE of man, as is well known, the outer condyle of the femur is remarkably elongated from behind forwards, and is broad and comparatively flat upon the under surface, though sharply curved behind (these features are not so well marked in the inner condyle, which bears less weight than the outer). Moreover the lateral ligaments are attached much nearer to the hinder than to the anterior surface, about one-third from the former and two-thirds from the latter (as indicated by the difference between the lines *ab* and *ae*, Pl. XIII. fig. 4). Hence, when the leg is brought to the extended position, and the tibia is beneath the broad flat surface of the condyle, the ligaments are quite tight, and the joint is locked tightly and securely. This arrangement, which contributes most materially to our stability in the erect posture, is quite wanting in the Chimpanzee. In this animal the outer condyle, as may be seen from the diagram of a vertical section from behind forward through it (fig. 5) and the drawing (fig. 6), forms simply a segment, and a considerable segment, of a circle at, or about, the centre of which (fig. 5 *a*) is the attachment of the lateral ligament. It follows, therefore, that neither the shape of the surface upon which the tibia moves, nor the point of attachment of the ligament, offer any restraint to the extension of the knee, or provide any greater fixity to the joint in one position than in others. This is a very remarkable feature showing, perhaps, more strikingly than any other, the unfitness of the animal to maintain the erect posture (even if it could attain it) for any continuance, or with any thing like the stability with which man is enabled to do so.

Secondly, in Man, the co-aptation of the articular surfaces and of the ligaments is such that they are *all*—the two lateral, the two crucial, and the posterior—quite tight in the extended position, so as to give the greatest possible strength to the joint in that position. Hence the division of any one of the ligaments in the dissected knee produces no appreciable effect upon the limit to extension. Indeed they may be divided in succession; and not till they have all been cut can the leg be carried forwards beyond the point of ordinary full extension. They all permit the movement up to this point; and all resist it beyond this point. In the Chimpanzee, on the contrary, I found the posterior ligament became tense first. When this was divided, a little further extension was practicable; and the posterior crucial ligament then became tight. A division of it allowed still further extension, till the anterior crucial ligament was tight; and upon the division of it the tibia could be carried quite forwards upon the femur, that is, the knee could be bent backwards without any hindrance from the lateral ligaments. The latter therefore have no real effect in limiting extension.

This difference in the effect of the ligaments in Man and the

Chimpanzee depends much upon the difference in shape of the condyle of the femur just alluded to; but it depends also upon the greater laxity of the ligaments in the Chimpanzee.

A *third* feature of difference resulting from these conditions is the greater freedom of rotation of the leg upon the thigh—the movement corresponding with pronation and supination in the upper limb. In Man there is no movement of this kind whatever in the extended or straight position. Whereas in the Chimpanzee it may be effected to some extent when the limb is straight; and in that slightly bent position, which is probably the extreme degree of extension that the animal can attain, the movement of pronation and supination is very free.

I say in that slightly bent position which is probably the extreme degree of extension which the animal can attain, because I found that the muscles did not admit of the knee being extended to a straight line without violence. The resistance was presented not a little by the semitendinosus descending to a low region of the tibia and sending off an expansion to the fascia of the leg[1].

The *Ligamentum mucosum* was strong and deep, indeed was continuous in the middle line with the synovial and areolar tissue in front of the anterior crucial ligament, so forming a complete septum extending between that ligament and the synovial membrane beneath the patella, and dividing the tibial part of the joint into two lateral compartments. The *Ligamenta alaria* formed crescentic bands arching from the upper part of the ligamentum mucosum and extending round across the front of the condyles, one on either side, so as nearly to meet in the middle. They thus partially separated the anterior, or patellar, from the posterior, or tibial, region of the joint, and encircled a wide foramen by which the communication between the two was established. The amplification and disposition of these ligaments, corresponding with their condition in lower animals and contrasting with their rudimentary nature in man, I need scarcely say, is to be associated with the incomplete extension of the joint in the ape.

It may be observed that the inferior surface of the two condyles is on nearly the same level when the thigh-bone is held vertically. In other words, the femur does not incline outwards from the knee to the hip as it does in man. Associated with this (see my treatise on the Human Skeleton, p. 482) is a want of projection of the anterior margin of the outer condyle.

In the ANKLE (figs. 1 and 2) the upper articular surface of the astragalus is less broad, flat, and square, than in man; the nar-

[1] The *Semimembranosus* had no connection with the fascia, but passed at some distance above it to its insertion. The *Gracilis*, as usual in monkeys, was very large and attached half way down the inside of the tibia.

rowing behind is more marked, and also the rising of the outer margin. The outer articular surface—that for the fibula—is larger and curved outwards at the lower part so as to subtend the lower end of the fibula, indicating that a greater proportion of weight is transmitted in that direction along the outer edge of the foot.

The hinder articular surface for the os calcis is very concave and oblique, receiving the correspondingly convex surface of the os calcis. Both are less flat than in man, and, therefore, like the ankle-joint, formed rather for movement than for endurance of weight. The head of the astragalus, projected upon its long neck, is almost spherical, and is lodged in the deep cup formed by the scaphoid, the os calcis, and the calcaneo-scaphoid ligament. Very free rotation of the foot takes place on this bone upon an axis passing from behind, forwards, inwards, and downwards, through the centre of the segment of the circle described by the articular surface of the os calcis and the centre of the head of the astragalus. The os calcis, as has been described by others, is small and terminates posteriorly, beneath, in one rounded surface instead of the broad bitubercular surface by which the heel of man rests upon the ground. Hence it inclines, or rolls, easily on to the outer side. It is moreover placed more externally than in man, a vertical plane from before backwards through its bearing point and through its middle coinciding with the fibula and with the ring toe; whereas in man such a plane coincides with the outer part of the tibia and the middle toe. In man such a plane (and it is the plane of gravity when we stand on one foot, and is represented by the line *a*, *b*, in fig. 3) bisects the ankle-joint and the posterior joint between the astragalus and the os calcis, dividing the respective articular surfaces into nearly equal lateral parts; whereas in the chimpanzee such a plane (*a*, *b*, fig. 2), cutting the fore part of the superior external prominent margin of the astragalus, has the whole of the oblique superior surface for articulation with the tibia and great part of that for the fibula on its inner side, as well as nearly the whole of the posterior joint between the astragalus and os calcis. This difference of the relation of the heel-bone to the ankle-joint is most important, inasmuch as the bone is thereby thrown out of the plane of gravity, its value as a basis of support is materially lessened, and it is reduced in great measure, like its correspondent in the lower mammals and like its homotype, the pisiform in the wrist, to a lever for muscles. To compensate for this position, the process which bears the anterior articular surface for the astragalus is produced inwards more than in man, is larger, receives a greater share of the weight, and, resting upon the ground in close union with the scaphoid bone and the calaneo-scaphoid ligament, transmits the weight directly to the ground. Moreover, the posterior surface for the astragalus, instead of being horizontal or with a slight

inclination outwards, is very oblique, slanting markedly downwards and inwards.

In man the weight received from the tibia (but little from the fibula) by the broad horizontal surface of the astragalus, is (one half in some positions, the whole in others) transmitted, backwards and downwards, through the posterior joint with the os calcis and through the heel-bone, the middle of all these being in the plane of gravity or nearly so; and the muscles pulling upon the tendo achillis operate in the reverse direction, through the same plane, in raising the heel and driving the body onwards. In the chimpanzee, however, these joints being oblique and in a plane internal to the projection of the heel-bone, very little weight is transmitted through the latter. It is chiefly transmitted in an almost directly vertical line to the ground; and the action of the calf-muscles upon the foot is oblique and unfavourable for raising weight or propelling the body. If, however, the foot be rotated so that the sole is turned inwards, then the projection of the heel is brought more in a line with the middle of the ankle-joint; and this is probably a chief reason for the outer edge of the foot coming first to the ground in these animals, as also for the sole being usually turned inwards when they are at rest.

The scaphoid bone is very shallow and curved, also large, thick, and produced internally. This part, with the calcaneo-scaphoid ligament, rests upon the ground, there being no plantar arch, and so transmits the weight directly to the ground instead of transmitting it along the metatarsal bone of the hallux, which, from its loose connection with the instep, is ill fitted to receive weight.

The internal cuneiform is relatively larger and of more square or parallelogram shape than in man, is situated lower, and projects more towards the sole so as to carry the hallux on a much lower level than are the other digits. Indeed the dorsal surface of the metatarsal bone of the hallux is a little below the level of the plantar surface of the other metatarsals. The anterior articular surface of the cuneiform bone is of a roller, or half cylinder, shape, with its axis directed downwards and a little backwards[1]; and in this direction the surface is nearly straight. In the transverse direction (from within outwards) it is sharply and uniformly convex. The cartilage is continued further upon the inner or tibial, than upon the outer side; it is slightly notched, contracting the width of the surface, in the latter direction. The only approach to the saddle-back form is caused by a slight elevation, or projection inwards, of the lower margin of the articular surface forming a 'stop' which prevents the metatarsal bone from being dragged from its position by the tibialis anticus, peroneus, and other muscles, and so enables those muscles to act more efficiently in

[1] This is well represented and described by Lucae, Die Hand und der Fuss, *Abhandl. d. Senekenb naturf. Gesellsch.* Bd. v. Taf. XXXVII. fig. 3.

inclining the hallux outwards and inwards. The articular surface of the metatarsal bone is concave and exactly adapted to it.

The position, direction and shape of this articular surface of the internal cuneiform bone is very important as determining the position and movements of the hallux. Being below the level of the articular surfaces of the other cuneiform bones it carries the hallux, as just stated, on a different plane from the other toes; and the plantar aspect of the hallux is directed, not like that of the other toes, downwards towards the sole, but outwards. The slightly oblique direction of the surface gives the hallux an oblique inclination away from the other toes; and the oblong transversely convex shape of the surface permits the movements of the hallux, though free, to be in one direction only, viz. in a plane at right angles to the long axis of the surface, that is, inwards (away from the other toes) and slightly downwards, and outwards (towards the other toes) and slightly upwards. In the latter movement it is carried quite athwart the toes so as to permit a body to be freely and powerfully grasped between it and them. In short, the mobility of the hallux in the Chimpanzee is attained by an arrangement of parts similar to that which we find provided for the movements of the pollex in the same animal and in Man.

Now, in the human foot, although the articular surfaces of the internal cuneiform and the metatarsal bone are shaped after the manner of those in the chimpanzee, they are more flat, permitting less revolving of the hallux upon the tarsus; and any such movement is greatly restricted or almost prevented, *first,* by the fact that the hallux is carried on the same level with the other digits and has the same direction with them, so that any movement outwards is impossible; and *secondly,* its head is bound to them by a strong transverse ligament (absent in the ape) which prevents any movement inwards. There is, therefore, practically, only a slight sliding of the metatarsal bone upon the tarsus just sufficient to give elasticity and prevent jars; and this bone, slanting downwards and forwards from the tarsus, forms the main support of the instep, and is the main agent in bearing weight and giving boldness to the step as we pass from one foot to the other in walking[1].

The articular surfaces of the heads of the metatarsal bones are less prolonged upon the dorsum in the chimpanzee than in man, which has relation to the manner in which the toes are bent upwards during the completion of the step in Man, a process which can be scarcely

[1] The movement of the great toe, which is acquired by some persons enabling them to hold substances between it and the other toes, consists of a lateral movement of the phalanges upon the metatarsus, corresponding with that which we can, to a greater or less extent, effect in all the fingers. It is therefore quite different from that of the metatarsal bone of the hallux upon the tarsus in the ape, and should not be compared with it as though it were at all homologous.

said to take place in the Ape. In this animal there is more power of flexing the digits towards the sole.

Are the peculiarities of the distal part of the hind limb in this and other members of the tribe sufficient, as they have been held to be by the older anatomists and by Blumenbach, Cuvier and Owen, to justify us in calling it a hand, and to warrant the application of the term 'quadrumanous' to these animals as distinguishing them from the 'bimanous' homo. Or is the hand-like character of the part, as maintained by Huxley, rather a superficial feature which is not corroborated by closer examination of the structure and, therefore, not to be used as a ground for scientific classification.

Our feeling with regard to this will, of course, depend upon what we mean by a 'hand' as distinguished from a 'foot'. If we take the human hand and the human foot as the standards for comparison, and require a similarity to the carpus and to the muscles, as well as to the digits of the human hand, in order to constitute a hand, there can be no question that the hinder extremity of the Ape does not fulfil the requirement. The tarsus and the digital muscles clearly resemble those of the human foot; and, in accordance with this mode of arriving at a decision, the part must be called a 'foot'.

But another view may be taken, which I suppose was the view of the older anatomists, though I am not aware that it has been explicitly stated by them, viz. that the part may be regarded as a hand, whether it be upon the hind limb or the fore limb, which presents a modification corresponding with that of the human hand as compared with the fore foot of other animals.

Now the features which distinguish a hand from a fore foot—take the fore foot of a Bear, a Dog or an Elephant—the characteristics, that is, of the hand do not consist in any special peculiarities, in the carpus or in the muscles—the arrangement of these is much the same in all—but in the elongation of the phalanges of the digits and in the shortness, mobility and the opposeableness of the pollex. This modification changes the part from a 'πους' or 'goer' into a 'χειρ' or 'holder'[1]. There is no need for an addition, scarcely even for an alteration, of a muscle; and the change in the bones is merely one of proportion as regards the digits, and of position of the trapezium and articulation of the metacarpal as regards the pollex.

In estimating, accordingly, the corresponding modification of the hind limb that is required to constitute a hand, we must not look for an alteration in the tarsal bones or in the muscles; these will probably retain the features which they usually present in this member, and which are different from those in the fore limb. The relatively larger size of the tarsal bones and the elevation of the astragalus

[1] πους is probably from the Sanscrit pad, to go, and χειρ with *αἱρεω*, I grip, from hri, to hold.

above its compeers to furnish the articulating surface for the leg-bones will probably remain as usual; and the muscles may preserve their ordinary disposition. The short flexor and extensor of the toes, the peronæus longus and the union of the flexor tendons of the hallux and of the other toes, may or may not be found. These are features, not especially of the *hand* or of the *foot*, but of the *hinder limb*[1]. What we shall expect to find will be a relative lengthening of the digits and a shortness, a mobility, and an opposeableness of the hallux.

The mobility of the hallux in the chimpanzee and its opposeableness have been sufficiently noted; and the mode in which these are brought about have been shown to be the same as in the case of the pollex. The shortness of the hallux and the lengthening of the digits are quite obvious. The proportions of these parts in the Chimpanzee as compared with Man were found to be as follows in two specimens measured.

		Chimpanzee.	Man.
From tip of heel to tip of toes	inches	6·6	9·5
„ length of phalanges	„	2·3	2·0
„ length of pollex with its metatarsal bone	„	3·0	4·6
„ length of second digit	„	4·2	4·7

Thus, it appears that in the chimpanzee the phalanges constitute more than one third, and in man, less than one quarter of the length of the part; the hallux in the chimpanzee is one third less than the other digits; whereas in man it is equal to them.

Taking, therefore, this view of the matter, and finding that the modification of the terminal part of the hind limb in the chimpanzee so clearly corresponds with that of the fore limb, we can hardly refuse to the one the appellation that we give to the other. If we call this a hand because its pollex is opposeable and its digits long, we have precisely the same reason for calling that a hand also; and the application of the term 'quadrumanous' to the animal is thus justified by real anatomy as well as by external configuration. There is, I think, clearly no sufficient anatomical objection to it.

It may, however, be urged that in neither of the limbs of the Ape is the office of the 'πους' lost or the full functions of the 'χειρ' assumed, that though both are 'holders' they are also 'goers', indeed, that they are holders chiefly for the purpose of going and aiding the movements among the boughs of trees which are the habitat of

[1] They are not all necessary conditions even of it. Both the short flexor and the short extensor were wanting in the Echidna Hystrix dissected by Mr Mivart. In a subject in our dissecting-room this winter a short extensor was found in each hand, arising from the lower margin of the radius and attached to the extensor tendons of the middle finger.

the animal, and that it would be better to indicate this by a term signifying neither hand nor foot, but a compromise between the two. Such a suitable term has been found in the word 'chiropod'; and the leaning of Zoologists seems to be in favour of it.

Whichever term is used it must not be forgotten that the configuration upon which it is based is not peculiar to the monkeys, but is common to them with some other tree-roving animals, such as Iguanas and Opossums.

And, for that is, after all, the important point, let not any alteration of nomenclature lead us to underestimate the vast teleological importance of the anatomical differences between the foot of man and the terminal part of the hinder limb of the ape. The size and mobility and direction of a toe may seem little matters; but incalculable sequences—the greatest that man can even now dream of—are involved with them. The size and straightness and fixity of the hallux, associated with the flatness of the femoral condyle already alluded to, give the bipedal and bimanous character to man. By enabling the lower limbs to do the whole work of bearing and carrying the body firmly, steadily and with agility, they set free the hand to be the minister and the promoter of intelligence; and we thus recognise in the large and firmly planted hallux the foundation stone of that structure which is the only fitting tenement of thought and responsibility, the only physical agent which can be supposed to have relation to eternal destiny.

I make this allusion to high function because I feel that if we divest anatomical science of teleological relationships we rob it of more than half its interest and of more than half its benefit as a subject of study—we, as it were, take the spirit out of the body. In comparing the limb of a Man with that of an Ape I cannot, and I would not, forget the high functions of the body of which it is a component. The so doing would be no gain to anatomy, but much loss to physiology. The interest of our study is so much increased if we find that great results follow slight apparent causes. If the rise of functional and psychical qualities in the human body is seemingly disproportionate to the physical differences between it and the body of the ape, it gives a higher meaning to those physical differences and sets a higher value upon the physical study; and, surely, in no part of its range does physical study reach so high as in the contemplation of those specialities of man's body with which the power of carrying out that and all other study is so closely related.

It may be that feelings of this kind induce me to search for and overrate, rather than ignore, the physical peculiarities of man. If they be viewed separately each may seem insignificant; but taken collectively, and duly considered in reference to their correlation and to the marvellous results attained thereby, they appear to me to

mark off the 'Homo' very definitely from the rest of the animal world. Further research may show closer connecting links. To our present knowledge he alone is 'bimanous', he alone is 'sapiens' or capable of becoming so, he alone in the biblical narrative is deemed worthy of a separate and that the crowning creative effort, the only fit recipient of the 'aura divina,' the only reflex of the willing, originating power. No wonder that he is by some Zoologists allotted a separate class in the vertebrate order.

The PROSTATE GLAND (figs. 7 and 8) was of moderate size, and shaped like a signet-ring, the anterior part being very narrow and containing but little glandular tissue. Laterally, it enlarged rather suddenly; and, behind, it formed a broad flat mass which was prolonged into an obtusely conical flap overlapping the vasa deferentia and vesiculæ seminales, and so forming a lobe external or posterior to them, the seminal ducts lying between it and the wall of the bladder. This 'posterior lobe' was easily reflected exposing the termination of the ducts which, in the latter part of their course, were situated in a broad fissure traversing the upper portion of the prostate transversely. The anterior wall of the fissure was formed by the fore part of the prostate which constituted the hinder aspect of the urethra; and the hinder wall of the fissure, which extended a good deal higher, was formed by the 'posterior lobe' just mentioned[1].

The vesiculæ seminales were long and their component coils loosely held together. The vasa deferentia contined separate from them till they had entered the fissure of the prostate and were about to pass into its substance.

The LARYNX (fig. 9), was of fair size, but the epiglottis was small, and did not rise freely above the level of the aryteno-epiglottidean folds. The vocal cords, though moderately pronounced, were very soft and flaccid, consisting almost entirely of mucous membrane with little elastic tissue in their substance. The sacculi laryngis were large, and prolongations of them extended more than half an inch upwards behind the false chordæ vocales to immediately beneath the margin of the aryteno-epiglottidean folds. A narrow prolongation (through which a bristle passes in the figure) of the upper and fore part of the right sacculus extended through the upper part of the thyro-hyoid membrane, on the right of the median line, and expanded into a pouch of the size of a hazel-nut, occupying the concavity of the strongly arched hyoid and projecting a little anterior to it. The opening into the pouch of the canal from the sacculus was surrounded by a wrinkled valve-like fold of membrane[2].

The TONGUE was large and its papillæ were well marked, especially the fungiform papillæ at the back; some of these were nearly a quarter of an inch long. The circumvallate papillæ were not disposed in a V figure, but twelve were in a row in the median line, their confluent circumferential margins forming a slightly raised band; and there were besides two on one side and one on the other[3].

[1] The animal dissected by Vrolik was young, and he observed nothing particular in the urinary or genital organs. The prostate gland of an Ateles Belzebuth that I dissected had a posterior lobe similar to that of the chimpanzee.

[2] In Vrolik's Chimpanzee, which was a young female, the pouch was larger, extended in front of the thyroid cartilage and communicated with the *left* sacculus. In the Orang there are large pouches, extending from the sacculi on both sides of the larynx down the neck in front of the clavicles, and insinuating themselves between the divisions of the pectoral muscles into the axilla. From several dissections of the Orang, Macaque, and other monkeys, Vrolik concludes that the pouches increase with age, and that they are larger in the male than in the female. In many of the quadrumana they are absent; and the purpose served by them is not very clear.

[3] The arrangements of these papillæ varies a good deal. In the Orang they are

The follicles on the back part and sides were very large, as also were those forming the tonsils.

The following are a few additional points:

The disposition of the ARTERIES in the lower limb was rather curious. It is well-known that in this class of animals the *anastomotica magna* is usually of large size, accompanies the saphena vein to the ankle, and supplies, to a greater or less extent, the district which in man is supplied by the anterior tibial artery, and sometimes even that which is supplied by the posterior tibial. This, probably, has relation to the outward bend of the knee and the inward direction of the hallux in these animals, which render the course along the inner side of the knee and leg the straightest, and therefore shortest, route for the arteries which are to supply the region of the hallux. In the Chimpanzee, however (the dissection of the arteries was confined to one of the two chimpanzees), the *anastomotica* on the right side supplied only the interval between the hallux and index, the rest of the lower part of the limb receiving its supply from the posterior tibial, which gave off branches, perforating the interosseous ligament, to the muscles in front; and, on the left side, it was small and did not extend below the middle of the leg, the last perforating branch of the posterior tibial taking the place of the terminal part of the anterior tibial in man.

The different degrees of approximation to the disposition in man, thus presented in the two limbs of the same animal, is highly interesting. So is the fact that the upper part of the anterior tibial artery of man is represented by one vessel and the lower part by another in the same limb, rendering it difficult to decide which should be regarded as its real homologue. Probably neither is strictly so, nature not being quite so rigid an adherent to homology as anatomists are sometimes inclined to make it appear. Such an arrangement of the vessels is by no means unfrequent[1].

It may be observed that as a general rule the muscles had broader attachments and were less distinct from one another than in man[2]. The connection of the glutæus with the outer head of the gastrocnemius is a good example of this. In like manner the muscular fibres extended further upon their tendons, giving less of that freedom and expression to the tendons upon which the comparative smallness of the joints and the beauty of the human figure so much depends. A similar want of distinct-

much as in man: in the Cat, Otter, Seal, Leopard, Lion, and Pig, there is more or less approach to the V shape; but in each arm of the V there are not more than three, two, or even one of the papillæ. In the Giraffe, the Ox, and the Sheep, they form a thick, raised ridge on either side of the back of the tongue.

[1] Vrolik found the disposition of the arteries in the Chimpanzee to be the same as in man. The femoral vein, however, divided upon the adductor *l*; one branch accompanying the artery into the ham, and the other following the course of the saphena. In Ateles I found the *Anastomotica* artery accompanying the saphena vein divide, in the upper third of the leg, into three branches: *one*, passing beneath the tibialis anticus and ext. propr. pollicis, took the place of the ant-tibial artery and supplied the dorsum of the foot; a *second* supplied the hallux; and a *third*, penetrating the fascia on back of leg, and crossing tibialis post. and flex. long. dig., took the place of the *post-tibial* artery in this situation, and divided into *plantar* arteries supplying the sole. The proper *post-tibial* artery was small, accompanied the nerve down the leg, and passed beneath tendo achillis to outer ankle.

Mr Nunn (*Obs. and Notes on the Arteries of the Limbs*, 2nd ed. p. 22) infers, from the distribution of the *anast. m.* to the fore-part of the foot in monkeys, that it is in man the analogue of the *radial*. The anatomy of Ateles would, upon the same ground, indicate it to be the analogue of the *ulnar* also.

[2] The deltoid was continuous with the triceps and brachialis anticus. The latissimus dorsi was connected, as usual in monkeys, with the triceps by a muscular slip (the *dorso-epitrochlian* of Duvernoy) passing at right angles from its tendon down the back of the arm. The anconeus was not distinct from the triceps. The long origin of the triceps extended nearly to the inferior angle of the scapula; the origin of the supinator longus half-way up the arm, the insertion of the coraco-brachialis nearly to the internal condyle, that of the semi-tendinosus half-way down the leg, &c.

ness or differentiation was observable between the fibro-cellular tissue and the fasciæ. The former was coarser, tougher and thicker than in man; the latter were for the most part less defined and strong, with less definite muscular connections, and seemed to play a less important rôle. (The tensor vaginæ femoris was well marked; but the glutæus max. had little connection with the fascia of the thigh, and the biceps brachii none with that of the forearm.)

The most important feature in the muscular anatomy of the lower limb was the absence (usual in the lower animals) of the *peroneus tertius*, which in man serves to raise the outer side of the foot and present the sole flat upon the ground. We associate this with the bearing upon the outer edge of the sole so generally observed in these animals.

An interesting example of the adaptation of the same means to varied purposes, which we find so largely displayed in the works of nature, is furnished by the fact that the movements of the hallux are effected, not by the introduction of any additional muscle, but by the different influence which the ordinary muscles exert upon the metatarsal bone in consequence of its peculiar relations to the tarsus. The *peroneus longus* and the *tibialis anticus* are the chief agents; and the influence of the latter as an abductor is increased by a more distinct division into two portions, and a more distinct insertion into the metatarsal bone than in man.

The *Gluteus maximus*, arising much as in man, and well developed over the buttock, was inserted into outer side of the femur below the trochanter and also into the tendon of origin of the vastus externus and so into the back of the femur (there is no distinct linea aspera) as low as the external condyle, where it was continuous with the outer head of the gastrocnemius and with the poplitæus. It had very little connection with the fascia. I did not discover any distinct *scansorius*.

The other buttock muscles were as in Man.

The *Tensor vaginæ femoris* and *Sartorius* arose from the anterior margin as well as the spine of the ilium.

The Adductor Longus arose from the spine and an inch of the margin of the pubes beneath Gimbernat's ligament, was inserted into the middle of the back of the femur; and a distinct prolongation of its tendon reached to the inner condyle. This is usual more or less, though not so distinctly, in man. There was a small opening in this tendon similar to that for the femoral artery in man. A small vessel only, however, passed through it; and the femoral artery itself traversed the interval between this tendon and the tendon of the adductor magnus to reach the ham.

The *Adductor magnus* was very large, arising as in man and inserted into the whole length of the back of the femur and into the popliteal space quite to the knee-joint, coming into contact with the outer part of the inner head of the gastrocnemius and the posterior crucial ligament. The portion which passed to the inner condyle was quite a distinct muscle arising separately from the tuber ischii and passing direct to the condyle.

The *Poplitæus* was large, as it is in many of the lower animals.

The *Gastrocnemius*, *Solæus* and *Plantaris* were in one chimpanzee disposed much as in man. In the other the only trace of the solæus was a small musculo-tendinous slip from the head of the fibula. This is usual in monkeys, and was found in the chimpanzee dissected by Huxley and Flower[1]. The tendon of the *plantaris* presented its peculiarity, admitting of being stretched into a membrane and drawn again into a rope. It had a separate insertion into the inner side of the os calcis constituting an approach to the extension into the plantar fascia observed in some animals.

In the foot the *interosseous* muscles, dorsal as well as plantar, were dis-

[1] *Med. Times and Gazette*, 1864, p. 42?.

posed in the same way as in the fore limb and as in the hand of man[1]. The *transversalis* was absent. The ulnar portion of the *Flexor brevis hallucis* was dwarfed by the large *Adductor*. *Tibialis posticus* tendon sent a strong band to ento-cuneiform and sheath of peroneus. *Accessorius*, absent on one side, was very small on the other, not reaching flexor tendon, but lost in the adjacent cellular tissue. (In the second Chimpanzee it was very small in both limbs. In Orang it could not be found. In Ateles it was very large.) The complicated relations of *Flex. l. pollicis, Flex. l. dig., Flex. br. dig.* and *Lumbricales* were much as they have been described by others[2].

The *Tibialis anticus* as usual divided into two muscles, one to the ento-cuneiform and one to the metatarsal bone (the latter is the *abductor longus pollicis* of Meckel). The anterior annular ligament was very strong for the purpose of resisting the pull, consequent on the commonly flexed condition of the ankle, which is related to the flexed condition of the knee. The *extensor* tendons were web-like, less separate than in man. *Peroneus brevis* sent a slip along edge of little toe joining extensor tendon.

UPPER LIMB. *Pectoralis minor* crossed over coracoid to great tuber-

[1] 4 *dorsal;* one to tibial side of index, 2nd to tibial side of middle, 3rd to fibular side of middle, 4th to fibular side of annularis: 3 *plantar;* one to fibular side of index, 2nd to tibial side of annularis, 3rd to tibial side of minimus. Found to be disposed in the same way by Duvernoy and Halford in the Gorilla and the Macaque, by Mivart in Cercopithecus, and by myself in the Dog.

[2] *Flex. l. hallucis* divided into 4 tendons; one to terminal phalanx of hallux, 2nd to fl. l. dig., 3rd to middle, and 4th to ring digit. *Fl. l. dig.* divided into 2 tendons to index and little digits. *Lumbricales* were 7; four from *fl. l. dig.*, one to tibial side of index, 2nd and 3rd joined tendons of *fl. br.* to middle and ring digits, 4th represented tendon of *fl. br.* to little digit, which was absent; three were from outer division of *fl. l. hallucis* to tibial sides of middle, ring, and little digits, joining the extensor tendons, that for middle digit derived some origin from *fl. l. dig.* In the Orang I found, as in Owen's Orang, that the great toe received no tendon from either of the long flexors.

These muscles usually encroach more or less on the ground occupied in man by the solæus; and in the Orang the outer of them had a considerable origin from the external condyle of the femur.

Prof. F. E. Schultze, of Rostock, gives in the *Zeitschrift fur Wissenschaft. Zoologie,* XVII. 1, an elaborate account of the arrangements of the tendons of the sole in Man and Mammals. In 100 dissections made for the purpose in Man he found that the outer division of the tendon of the Fl. hallucis l. passed in 32 instances to the 2nd toe only, in 58 to the 2nd and 3rd toes, and in 10 to the 2nd, 3rd, and 4th. In 29 instances a slip from the Fl. l. dig. passed to the inner division of the Fl. l. hallucis (the division destined for the hallux). This occurred most frequently in the instances in which the Fl. hallucis was distributed to the 2nd, 3rd, and 4th toes, as though to compensate for the loss of substance sustained therefrom. Usually the disposition was the same in the two sides. (These results correspond closely with those obtained by Turner from the dissection of 50 cases, *Ed. Phil. Trans.* XXIV.) The relation of the two tendons to the several toes being of this nature, he thinks that the terms Fl. dig. fibularis and tibialis should be substituted for Fl. l. hallucis and digitorum, especially as in some mammals the former muscle has no connection at all with the hallux; and in some (the Mole, the Hedgehog, and others, pp. 13 and 14) the two muscles or their tendons are blended into one, from which the tendons proceed to all the toes. In the Marsupial Didelphis with opposeable hallux the Fl. fib. passes to all the digits, the Fl. tib. to all but the 5th. The Kangaroo has only one flexor for its two large and two small toes.

He found occasionally (as has been observed by Wood, Turner, and others, and in the Bushwoman, supra, p. 204) a small spindle-shaped muscle arising from the plantar surface of the Fl. tib. in man, and passing to the 5th digit, joining the division of the short flexor to that digit, when it was present, or taking its place when, as sometimes happened, it was absent; a similar muscle passed also occasionally to the 4th and even to the 3rd digit, but not to the 2nd. He compares this variety with the frequent limitation, in monkeys and other animals, of the flex. br. to the 2nd digit, its place in connection with the 3rd, 4th, and 5th digits being supplied by a muscle or muscles arising from the Fl. tib. The Lumbricales are sometimes, in addition, present, sometimes absent.

In connection with the usual disposition of the flexor tendons in the sole of Man he mentions and represents, Taf. 1, fig. 4, the union of the Fl. l. pollicis and the Fl. l. dig. as an occasional variety in the hand.

See also Rev. S. Haughton in *Proc. Royal Irish Acad.* I. 710.

cle of humerus, representing, perhaps, the most frequent disposition of this variable muscle in monkeys. This disposition, advantageous to the animals in swinging by the limb, has probably relation to the depressed character of the coracoid in them as compared with its forward projection in man. It is the usual disposition in animals (the Dog, Sheep, &c.) in which the coracoid is very short and does not project on the inner side of the shoulder joint.

The movements of the metacarpal bone of the thumb were well provided for by muscles disposed much as in man: but the provision for the movements of the phalanges was not so good. The only trace of *Flexor l. pollicis* being, in one Chimpanzee, a slender tendon passing from the fascia of the palm to the terminal phalanx[1], and, in the other, a long thin tendon passing from *inner* or *ulnar* part of flex. dig. prof. to terminal phalanx[2]. This is a little remarkable, seeing that even the diminutive pollex of the dog has its distinct long flexor muscle. The ulnar division of *flex. brevis* passed to the terminal phalanx. Moreover, of the three *extensores pollicis* one passed to the scaphoid and the metacarpal, the 2nd also to the metacarpal, and the 3rd to terminal phalanx. This more or less complete absence of the long flexor and the insertion of the 2nd extensor into the metacarpal, causing the thumb to move as a whole, is not uncommon in quadrumana. The *extensor* tendons of the fingers were web-like, and the *ext. indicis* sent a slip to middle finger. The space upon the radius which in man is devoted to the *flex. l. poll.* was, as usual, occupied by the portion of the *flex. profundus* passing to the index; this muscular derivation from the thumb to the fingers corresponding with the greater proportionate strength of the latter[3]. *Palmaris longus* was expanded into the fascia at the lower part of forearm. *Palmaris brevis* was large.

The osseous provision for the movement and opponency of the thumb is the same as in the human hand and corresponds with that in the foot, viz. the position of the trapezium carrying the thumb in a different plane from the other digits, and the shape of the articular surface, which is strongly convex from before, backwards and slightly concave in the other direction, adapted to the sharply concave and slightly convex metacarpal.

The joints of the carpus with the metacarpus and with the radius and ulna, also the lower radio-ulnar joints, were much as in man. The inner part of the scaphoid and the adjacent portion of the trapezium were much produced inwards, and there was a small additional (pisiform) bone between them. In the upper radio-ulnar joints the orbicular ligament was less

[1] This was the case in the Gorilla, dissected by Huxley, *loc. cit.* p. 538.

[2] This crossing from the *ulnar* side to the pollex reminds us that in the lower limb the flexor muscle always crosses from the outer or *fibular* side to the hallux. In a male subject, in our dissecting this winter, a small muscular slip from the ulnar part of the *flex. sublimis dig.* passed beneath the median nerve, sent a narrow tendon to the *fl. l. pollicis*, ran down in company with that muscle to beneath the annular ligament, where it disappeared in the cellular tissue. See Turner, *On Variability in Human Structure*, *Ed. Phil. Trans.* XXIV. p. 179.

[3] In Prof. Wilder's Chimpanzee and Duvernoy's Gorilla the portion of *flex. prof.* supplying index was separate from the rest and joined with *fl. l. poll.* When the latter is present it generally comes from the common flexor. In two specimens of the Macaque, Prof. Halford (*Lines of Demarcation between Man, Gorilla, and the Macaque*, p. 17) found it as in Man; in a third it was conjoined with flex. prof. dig.; in all it was the weakest of those inserted into the last phalanges. This incipient blending of the flexors of the digits which attains its maximum by their fusion into one muscle in the fore as well as the hind foot in Monotremes, some Edentates, and other animals (Mivart, in *Trans. of Linnæan Society*, XXV. 389 and 394; Schultze, footnote, p. 266) is interesting. See also Rev. S. Haughton, in *Proc. of Royal Irish Acad.* I. 714.

It was remarked by Prof. Wilder (*Boston Jour. of Nat. Hist.* VII. 364) that the tendons of *flex. pr. dig.* were so short as not to permit the simultaneous extension of both hands and fingers, so that the mere weight of the body upon a branch extending the hand will cause the fingers to close like hooks upon it, and enable the animal to retain its hold without muscular exertion.

strong and did not form so distinct and flat a band as in man. The circumferential margin of the end of the radius was less deep and not quite so circular, and its hinder edge rose a little above the general level. This prevented supination from being quite so free as in man, though it is, perhaps, freer in the chimpanzee than in any other of the quadrumana.

DESCRIPTION OF PLATE XIII.

Fig. 1. Drawing of right hind foot of Chimpanzee with the hallux and the astragalus thrown back to show the articular surfaces of the metatarsal bone of the hallux and the ento-cuneiform and of the astragalus and the os calcis.

Fig. 2. View from above of the same part; *ab* is a line drawn forwards through the bearing point and body of the heel-bone and the ring digit.

Fig. 3. Similar view of human foot. The line *ab* drawn through the bearing point and body of the heel-bone and continued forwards bisects the posterior calcaneo-scaphoid joint and the upper articular surface of the astragalus and traverses the second toe.

Fig. 4. A diagram of a vertical section from before backwards through the middle of the outer condyle of the human femur. *a* indicates the point corresponding with the attachment of the external lateral ligament. The equality in length of the lines *ac*, *ad*, and *ae* show *a* to be in the centre of the circle described by the hinder part of the condyle; and the length of the line *ab* shews the distance of the ligament from the front of the condyle.

Fig. 5. Diagram of similar section in Chimpanzee. The line *ab* being of equal length with *ac*, *ad*, and *ae* shows the attachment of the ligament to be as near the anterior as it is to the other parts of the surface of the condyle.

Fig. 6. Drawing of outer side of lower end of Chimpanzee's femur. The large and deep depression for the attachment of the external lateral ligament is at the middle of the surface of the condyle.

Fig. 7. Hinder view of the bladder, prostate, vasa deferentia, vesiculæ seminales, and membranous and bulbous portions of the urethra of the Chimpanzee. The conical 'posterior lobe' of the prostate is seen projecting up behind the seminal ducts.

Fig. 8. The 'posterior lobe' of the prostate is turned down showing the transverse fissure and the vasa def. and sem. ves. passing across it.

Fig. 9. The tongue, tonsils and larynx of Chimpanzee. The right sacculus laryngis has been freely opened by a vertical cut through the superior, or false chorda vocalis, and a bristle passed through the opening from it into the laryngeal pouch.

ON CASES OF VAGINA DUPLEX ET UTERUS SIMPLEX AND OF SACCATED UTERUS. By J. MATTHEWS DUNCAN, M.D., F.R.S.E., &c. &c.

I HAVE, in my own experience, met with several kinds of malformation of the female genital organs. Among such cases, none have been more remarkable than those of double vagina. I have seen three cases of vagina duplex. Of one of these, I had the misfortune to get only an imperfect examination: it was probably a case of *vagina duplex et uterus duplex;* and therefore does not come into the same category with the other cases given in this paper. But I may mention that, in it, the right vagina was of ordinary size, while the orifice of the left would not admit the little finger. The orifice of the left was like a very large urethral orifice, and its centre was considerably anterior to the centre of the other vaginal orifice, being nearly in a line with its anterior margin. A large sound, passed through the smaller orifice, could be easily felt through the left wall of the chief vagina, passing as high as the uterine cervix. This smaller vagina had no communication with the other. The genital organs were healthy.

The first case of *vagina duplex et uterus simplex* that came under my notice was in a lady who had come from a distance to be confined of her first child in Edinburgh. The nature of the case was recognized during labour, but not at first. There was a greater sensitiveness of one passage than of the other, a circumstance which, while the condition of parts was unknown, caused some anxiety; for, then, it was only a greater sensitiveness on some examinations than on others. But as the second stage progressed, chloroform was administered, and careful investigation of the parts instituted. The duplicity of the passage was then made out. But already it was impossible to say how high the dissepiment between the two passages was carried. For the advancing fœtal head pushed the dissepiment before it, apparently without lacerating it, as happened in the case recorded by Dr Cappie. When the head presented at the vaginal orifice, it was checked by the dissepiment, now crumpled up from above downwards, and elongated from before obliquely backward and to the left side. Both vaginal orifices were distended, but the right was the largest.

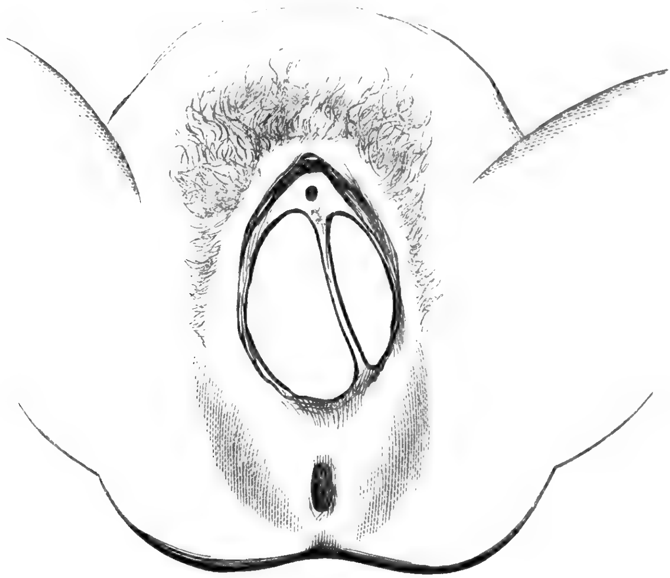
Wishing to avoid laceration of the dissepiment, I cut it through, and the child was soon born thereafter. It was evident that the right vaginal orifice was used in cohabitation, while the left was not; and probably on that account, it was more sensitive than the right, on a digital examination being made.

This case presented another rare anomaly. Before the child was born and especially during a pain, a sort of hour-glass contraction

could be distinctly felt. Above the ordinary outline of the large uterine body, and inclining towards the left hypochondrium, could be

Fig. I.

Shewing the vulva as distended by the advancing fœtal head.



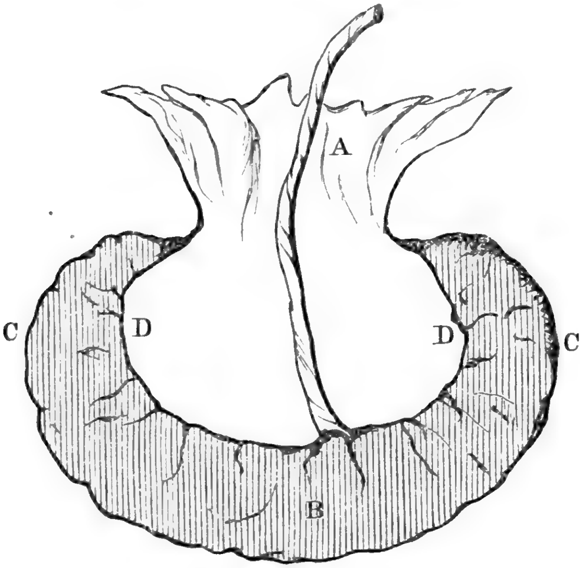
perceived a mass somewhat larger in size than a cocoa-nut, connected with the mass of the uterus by a considerable neck and not moveable separately from that organ. This condition persisted until the separation of the placenta, when it could no longer be felt. It was therefore only in form an hour-glass contraction; in most other points of its history it differed from that well-known state of the uterus occurring after the birth of the child. This condition may be called 'a saccated uterus'; and within the sac the placenta grew.

The condition of the placenta was curiously demonstrative of the saccated state of the uterus and of the site of its own insertion, for, only by assuming these two points as described, can the condition of the placenta be accounted for. Laying it on a board, it had the shape of a flattened globe. Its external or uterine surface touching the board, little else than external or uterine surface could be seen. From the upper surface of the spheroidal mass, as it lay on the board, could be seen emerging membranes and cord, a considerable edge of the upper surface being the marginal part of the external or uterine surface of the placenta. It is evident that the placenta had grown within the sac, and that, during pregnancy, the membranes

and cord passed through the neck of the sac to be continuous with the rest of the involucra and funis.

Fig. II.

Shewing a plan of a section of the placenta.



A. *Lacerated membranes.*
B. *Placental mass.*
C. *External or uterine surface of placenta.*
D. *Internal or membranous surface of placenta.*

I shall not enter on any speculations as to the anatomy of this sac. The lady still lives, the mother now of several children not delivered under my superintendence, and any guessing as to the nature of the sac is vain, from want of such positive information as only an autopsy could afford. I shall only say that while the saccated condition may appear to some to indicate partial duplicity of the upper part of the uterus, it may by others be ranked with those curious cases of gestation, in which the placenta has been described as developed in a Fallopian tube while the fœtus grew in its normal site, or in which some other like anomaly has been represented as occurring[1].

Peu, in the fifteenth chapter of the second book of his *Pratique des Accouchemens*, published at Paris in 1694, describes a case of incarcerated placenta which he saw only after the birth of the child. His words shew that he evidently thought that the placenta had

[1] For some remarks and references, see the *Edinburgh Medical Journal* for June 1856, p. 1059.

been encysted during pregnancy or developed in a uterine sac; but there is nothing stated in the history of the case, or in regard to the anatomy of the placenta, which confirms his view; and the frequency of incarcerated placenta, as compared with the extreme rarity of saccated uterus, renders it highly probable that the case was merely one of incarcerated placenta such as is not very rarely seen in cases of hour-glass contraction. Error of an opposite kind, yet somewhat analogous, was in vogue about the same time in regard to placenta prævia, the placenta being supposed to have fallen accidentally during labour into the situation in which it really grew. Peu's words are as follows, and are both ingenious and important, whatever may have been the real nature of his medical colleague's wife's case.

"En l'année 1671, Monsieur Martin l'aîné, mon confrére, me fit l'honneur de m'apeller au secours de sa premiére femme, que je trouvai accouchée d'un puissant enfant, et non délivrée; car son délivre étant retenu et enfermé du côté droit plus haut que le fond de sa matrice, comme si la nature lui en eût fait une seconde: sa sage-femme y trouva de la résistance, et lui résistant ellemême à son tour, rompit le cordon dans sa racine. Je ne la blâme pas d'avoir ignoré cette constitution de matrice peu ordinaire et inconnuë à bien d'autres qu'elle: cette ignorance n'est pas un crime; mais de n'avoir pas demandé du secours dans une ocasion où elle trouvoit un si grand obstacle. Je m'en plains, parcequ'en efet son imprudence non seulement jetta son accouchée dans la perte de sang, les hoquets continuels, les syncopes, et les sueurs froides, où je la trouvai: mais rendit aussi pour moi la démarche fort épineuse. Heureusement pourtant nous en sortîmes la malade et moi: elle revint en santé, et je fus depuis mandé en quelquesuns de ses travaux pour lui ménager la vie.

"La curiosité pourrait obliger quelqu'un à demander, comment un enfant peut subsister dans la matrice, aiant son délivre en un lieu séparé. Je répons là dessus, que c'est une de ces merveilles dont l'Auteur de la nature s'est réservé la connoissance. Je ne dirai point comment cela se passe. Peut-être le fétus et ce qui le suit est-il contenu d'abord et même engendré et formé dans ce lieu particulier dont nous parlons, et qu'ensuite le tout ne pouvant demeurer dans cet espace l'arriére-faix y reste, et le fétus décend sur les dernieres mois dans la matrice avec le tout, ou une partie des eaux; sans cesser pour cela de recevoir ce qui lui est nécessaire, tant pour subsister que pour se perfectionner: ni que rien empêche une libre communication entre le fétus, les eaux où il surnage, les membranes, qui contiennent ces eaux, et la masse où ces membranes sont appliquées. Quoi qu'il en soit ces sortes d'apotheques ou arriére-boutiques, m'ont toujours paru l'une des plus rares choses de ma profession; et si je les ai trouvées garnis d'une espéce de marchandise de contre-bande qui m'a donné bien de la peine à faire passer: en recompense je me suis dédommagé sur le plaisir que j'ai eu d'en faire la découverte à mon égard, et d'y acquerir certaines lumiéres dont j'ai bien sçu me servir ailleurs[1].

For my second case of double vagina with single uterus, I am indebted to Dr Warburton Begbie. The lady who was the subject

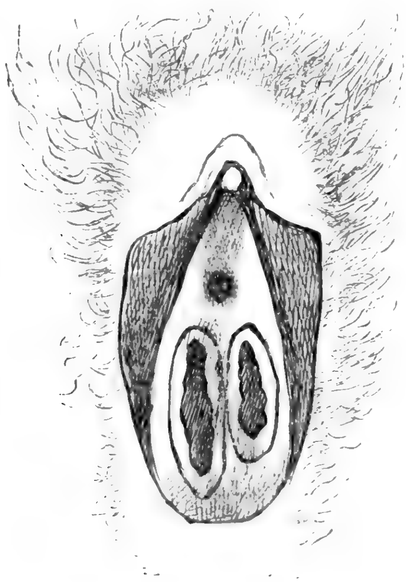
[1] See some remarks on Peu's case by Baudelocque, *System of Midwifery*, Heath's Transl. Vol. II. p. 29.

of it had been recently married. She menstruated irregularly before marriage, the intervals between the periods being much exaggerated; but since her marriage the menses had recurred regularly with the usual interval. Her husband and she thought that there must be some unusual condition, because connexion never seemed to be complete, and because attempt at connexion was sometimes painful.

An examination at once discovered the state of matters. It was as follows. There were two vaginal orifices; the right of ordinary size; the left only of capacity enough to transmit the finger easily.

Fig. III.

Shewing the vulva with the right and left vaginal orifices.



The right vagina was not unusually sensitive; the introduction of the finger into the left was at least very disagreeable to the patient. Each vaginal orifice had a well-developed frill-like hymen, a circumstance contradictory of the opinion of Hyrtl as to the absence of this membrane in such cases[1]. The septum between the vaginæ was thin, having however a thickening at its upper free end and at the part separating the lower orifices. The septum ended at the os uteri, the two vaginæ joining there. A finger could be passed through either vagina, bent over the upper edge of the septum and pushed into the

[1] "In Forensischer Hinsicht kann es wichtig sein zu wissen, dass bei angeborener Duplicität der Vagina der Hymen ohne ausnahme fehlt." *Handbuch der Topograph. Anat.* Von Joseph Hyrtl. *Zweite Auflage*, II. Band, S. 103.

other vagina. The vaginæ were short, and, like the septum, measured only an inch and a half in length. When I first examined her she was pregnant. In the middle of her pregnancy I divided the septum with a wire ecraseur in the presence of Drs Warburton Begbie and Russell, in order to avoid its laceration or artificial division during labour.

Labour was natural and easy. During it, the remains of the septum were easily felt in the form of a long crest on the anterior vaginal wall. As labour advanced, the lower part of this crest was protruded from the vulva, forming a considerable mass. During the delay of the child's head as it distended the perineum, this lower part of the remains of the septum increased in bulk and in hardness till it nearly equalled in dimensions the half of an erect penis.

Bands in the vagina, extending more or less directly from before backwards, have been described as partial dissepiments analogous in developmental origin and history to the septum of a double vagina. I have met with such bands, and observations of a like kind have been made by others[1].

[1] Busch: *Geschlechtsleben des Weibes*, III. Band, S. 159; Förster: *Die Missbildungen des Menschen.* Atlas, Tafel XX. Fig. 17; and by Dr Alexander Simpson: *Edinburgh Medical Journal*, Vol. IX. 1864, p. 957.

Kussmaul describes similar hymeneal bands: *Von dem Mangel, der Verkümmerung und Verdoppelung, &c. der Gebärmutter*, S. 176, and gives references to cases recorded or described by Moench, Senn, Mende and Oldham. Klob, *Pathologische Anatomie der Weiblichen Sexualorgane*, S. 417, also describes them and cites a case of Campbell's. See also Kelch, *Beyträge zur Pathol. Anat.* S. 55.

Many authors have, in their works, noticed the occurrence of cases of vagina duplex et uterus simplex, and have described some curious varieties of the condition, the chief of which are varying lengths of the dissepiment, closure of one of the vaginæ at its upper extremity or imperforation at the lower. Among these authors may be mentioned, Murat, *Dictionnaire des Sc. Med.* Tome LVI. p. 455; Rokitansky, *Pathological Anatomy*, Sydenham, Transl. Vol. II. p. 265; Kiwisch, *Klinische Vorträge*, Abth. II. S. 374; Farre, *Cyclopædia of Anatomy and Physiology*, Vol. V. Suppl. p. 707; Courty, *Traité pratique des Maladies de l'uterus et de ses annexes*, p. 123.

The following references to cases of vagina duplex et uterus simplex are here given. I report them without pretending that the collection is complete, or placed in order. In the passages indicated, further references are given to the cases in connexion with which only the observer's name is given by me.

Busch, *Geschlechtsleben des Weibes*, III. Band, S. 159, mentions his having met with cases, and refers especially to a case by Stein and to another recorded in Rust's *Magazin.* Meissner, *Frauenzimmerkrankheiten*, I. Band, S. 346, notes a case by Callisen and another by Bartholin. Kussmaul, *Von dem Mangel, der Verkümmerung und Verdopplung der Gebärmutter, &c.* S. 176, cites cases recorded by Morgagni, Sixtus, Lemonier, Zentel, Carter, Guyot, Godard and Dunglas. Förster, *Die Missbildungen des Menschen.* Atlas, Tafel XX. Fig. 16, gives a figure of a case. Maunoir, *Monatsschrift für Geburtskunde*, II. Band, S. 503, records a case. Lastly, a very interesting case, where the malformation occurred as a complication of labour, is narrated by Cappie, *Edinburgh Medical Journal*, 1864, Vol. IX. p. 956.

ON THE RECENT RESEARCHES CONCERNING THE SUGAR OF MUSCLE. By Robert McDonnell, M.D., F.R.S., &c. &c.

Dr J. Ranke, of Munich, in his work "On Tetanus," which is indeed an elaborate treatise on the chemistry of muscular action, has added some important facts to what was already known on the subject of muscle-sugar. In the following pages I wish to lay briefly before the readers of this *Journal* a short history of this interesting subject, and particularly to direct attention to Ranke's researches, which appear to me to have much practical as well as scientific value.

In August 1861 G. Meissner announced his discovery of a true sugar in muscle. This discovery was communicated to the Royal Society of Sciences at Göttingen, in a preliminary statement entitled "On our Knowledge of the Metamorphosis of Matter in Muscle." In the reports of the University of Göttingen for 1862, No. 10, he confirms his first statement: in fact, he here alludes to having exhibited the sugar in substance. The demonstration of sugar in muscle must be regarded as one of the most beautiful of the recent discoveries of physiological chemistry. It affords a basis for the most comprehensive theories as to the mode of decomposition of albuminous matter; and such inferences Meissner did not fail to draw. He sought by two methods, which appear conclusive, to establish with certainty the view that the sugar in muscle is in truth derived from this organ itself (and not from the blood); and secondly, that it is a product of the decomposition of albumen.

He found sugar to exist in the muscular tissue of an animal which had for a long time been fed exclusively on flesh, and, what was still more conclusive, he detected it in muscle from which all blood had been removed by the injection of water. The sugar therefore appears to be derived from the muscular structure itself, and it is certainly highly probable that it owes its origin to the albumen.

When Dr Johannes Ranke undertook to investigate the chemical changes which occur in muscular tissue, in consequence of muscular action, it was natural that so well characterised a substance as Meissner's muscle-sugar should attract his attention. He therefore determined not only to repeat the experiments of Meissner, but to investigate whether the quantity of sugar in muscle undergoes any change in consequence of muscular action; in other words, whether after tetanization of muscle the sugar contained in it was found to be increased or diminished in quantity.

The question seemed capable of being easily decided, as the method which Meissner had employed in the qualitative demonstration might with facility be converted into a mode of quantitative estimation. Meissner, in demonstrating the presence of sugar made use of the fermentative test, and also the cupro-potassic, that is, the reduction of oxide of copper to the state of suboxide by the presence of sugar in an alkaline solution.

In speaking of the latter method Meissner in his first Essay says: "It is very difficult to free the sugar of muscle from certain nitrogenous substances, such as creatine and creatinine, which, like ammonia, retain the nascent suboxide of copper in solution, hence the suboxide of copper rarely separates: in the majority of instances, where the suboxide remains in solution, it is necessary to acidify the solution with hydrochloric acid and to test it with a freshly prepared solution of ferridcyanide of potassium; the red precipitate of ferridcyanide of copper indicates with certainty the presence of suboxide of copper."

Ranke converted this method of detecting the existence of sugar into a mode of estimating it quantitatively: and this he accomplished in the

following manner. He prepared a very dilute solution of pure sulphate of copper in water of caustic potash; the fluid was of a beautiful blue colour, and 0·2 cc.[1] of it added to 20 cc. of a watery extract of muscle communicated to the latter a distinct blue coloration. The extract was contained in a very small glass flask, in which it was raised to the boiling point; to the boiling watery extract the solution of copper and potash was added in drops until no further decolorization of the fluid took place; the maximum of the possible limits of error was therefore determined to be between 0·1 and 0·2 cc. This result was subjected to still further scrutiny; some Swedish filtering paper was soaked in a solution of ferridcyanide of potassium in hydrochloric acid, which for this purpose should always be made fresh; one drop of a mixture of 0·1 cc. of the cupro-potassic solution in 20 cc. of water gave on this paper a distinct brownish-red precipitate, surrounded by a reddish yellow ring caused by the action of the potash. A solution of the suboxide of copper did not give this reaction. This test-paper therefore afforded a means of recognizing an excess of unreduced solution of suboxide of copper; indeed, of discovering with certainty even so small a quantity as 0·1 cc. of it.

By the aid of a process yielding such extremely delicate results Ranke hoped to be able to demonstrate even very minute differences in the amount of sugar present in muscle before and after it had been submitted to muscular action.

Before, however, entering on this investigation it appeared advisable to Ranke to verify the primary discovery of Meissner; in short, to satisfy himself with his own eyes that sugar is really present in the juice of muscle. For this purpose he chose the fermentation method with the view of obtaining the alcohol produced from the fermented fluid. As the verification by an independent observer of an important new fact is the next most valuable thing to its discovery, I shall give the details of Ranke's experiment in his own words. "I took four pounds of meat as free as possible from blood (veal from which almost all the blood was removed in slaughtering the animal), cut it up as finely as I could, and boiled it with an equal weight of distilled water until all the albumen was completely coagulated. The almost perfectly clear acid fluid, which possessed in a high degree the property of reducing oxide of copper to the state of suboxide, was mixed with some yeast (which had by washing been perfectly freed from all the sugar contained in it; when boiled and filtered it no longer possessed any reducing property), and placed in the fermenting room. In order to make the development of carbonic acid from the broth quite evident to the eye, a little flask with barytic water was attached to that containing the fluid. The development of carbonic acid commenced in a few hours after the broth was placed in the fermenting room, the acid rose in little bubbles, and the baryta water began to become turbid. In twelve hours the fermentation was in full operation, at the end of 36 hours it had terminated.

"After the lapse of 72 hours the soup was removed from the fermenting room, in order to be further examined. The fluid smelt of rotten cheese, and had a strongly acid reaction; and, a point on which I am constrained to lay great stress, it even *after the fermentation of the sugar still reduced the alkaline copper solution.* This acid fluid was subjected to distillation in a spacious retort, the precautions required in the distillation of small quantities of alcohol being duly attended to. By quadruple distillation a small quantity of a fluid was obtained, which by its inflammability, low specific gravity &c. was recognized as alcohol."

The demonstration of the formation of alcohol and carbonic acid was enough to show, without doubt, that the substance contained in the juice

[1] cc. indicates cubic centimeters.

of meat, capable of reducing the oxide of copper in an alkaline solution to the state of suboxide, was at least in great part a fermentable and veritable sugar.

It is, of course, very well known that there are several substances besides sugar which possess the power of reducing to the state of suboxide the copper of the cupro-potassic solution. The investigations of L. V. Babo and G. Meissner are precise on this point. Now, as Ranke found that even after all fermentation was at an end and all sugar decomposed, nevertheless the extract of flesh still retained the property of reducing the oxide, before he could proceed further in his very delicate researches, it became necessary for him to ascertain what organic substances besides sugar possess this property.

He confirms the statement of Babo and of Meissner, that pure uric acid possesses this power in a high degree; he agrees also with the same investigators in stating positively that urea and hippuric acid do not possess this property. He has satisfied himself of the *non*-reducing quality of lactic and cynuric acids, of guanin, leucin, pyroxin, and strychnia, which last-named base it was necessary to submit to careful examination, inasmuch as it was the agent to be used for producing the tetanization of the muscles in experiments hereafter to be detailed.

It has been already stated that creatin and creatinin possess a double property, 1st, that of reducing the oxide of copper to a state of suboxide, and 2ndly, that of retaining the so-formed suboxide in solution, from which it may, however, be precipitated by means of ferridcyanide of potassium. It appears, therefore, that there are present in muscular juice three substances which are capable of effecting the reduction of the oxide of copper, viz.

1st, Sugar.
2nd, Creatin.
3rd, Creatinin.

All quantitative determinations therefore made by examination of muscular juice by the cupro-potassic test must give a general result, being the reduction caused by all these three substances.

The fermentation-test, however, places within our reach a means of determining the amount of sugar apart from the other two.

Availing himself of this latter process, Ranke undertook an extensive series of experiments, in which, having got rid of the sugar by fermentation, he attempted subsequently to determine the amount of reduction performed by the creatin and creatinin which remained. He found this to be very slight indeed: so slight as to be incapable of quantitative estimation. He came, therefore, to the conclusion that in his future experiments it would be allowable to refer the reducing power of the muscular juice exclusively to the sugar, as the very small share which the other two matters take in the reduction completely disappears in comparison to that of the sugar.

The volumetric strength of the copper solution which he used was such that 1 cc. of cupro-potassic solution corresponded to 0.000366 grammes of sugar.

Having in this manner verified and extended the primary observations of Meissner and L. V. Babo, Ranke was in a position to undertake very accurate experiments concerning the important questions already indicated, viz.

1st. What may be the amount of sugar to be discovered in muscular tissue which has been in a condition of repose as compared with muscle which has been in action?

2nd. Where is the sugar found in muscle formed?

In order to solve the first of these problems a number of experiments were performed, all of which lead to the same general conclusion, viz. that sugar is developed in muscle as the result of muscular action.

It is hardly necessary to mention that in all instances care was taken to remove all blood from the muscles. The results of the reduction were calculated with reference to the sugar alone (omitting creatin &c.). The strychnine used for purposes of tetanization has been already pointed out to be a non-reducing material, it is therefore an agent which cannot be supposed to have interfered with the accuracy of the results.

The first experiment I quote in detail. For this experiment six frogs were employed; three of these were tetanized with strychnia, the other three were simply killed instantaneously. From both sets of frogs 100 cc. of fluid were prepared from 25 grammes of flesh; that is to say, a watery extract was made, every twenty cc. of this fluid were tested as to their reducing power, 3 cc. of the copper solution being added both to the fluid obtained from the frogs at rest, *No. I*, and to that from the muscles of the tetanized animals, *No. II.*

The result was as follows:—

1. I. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling still of a deep blue.
2. II. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling completely decolorized.
3. I. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling still blue.
4. II. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling completely decolorized.
5. I. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling still blue.
6. II. 20 cc. of the liquor carnis with 3 cc. of the copper solution, after boiling completely decolorized.

This simple experiment shews that the reducing power of the liquor carnis obtained from muscle which has been tetanized is greater than that derived from muscle which has remained in a condition of repose. As to the quantitative relations of this increase it affords no data, yet even so arranged it is instructive, and is particularly adapted in the quickest and simplest manner to establish the fact of the increase of the sugar in consequence of muscular action. While with the addition of a given amount of copper solution the liquor carnis from the muscle which remained at rest continues blue, that from the tetanized muscle is completely decolorized.

Ranke's next step was to convert the result of this experiment into an accurately quantitative one. By a very elaborate and carefully conducted series of experiments, the details of which are too long to enter into, he confirmed the general result of an increase of the sugar in muscular tissue in consequence of muscular action, and proved, further, that on an average this increase amounts to 41 $^0/_0$.

It now remained to determine experimentally where the sugar is formed, which is found to be increased in muscle by muscular action. Meissner's theory being that muscle-sugar is the product of the decomposition of albumen, it became necessary to examine whether this sugar is formed in the muscle itself, or whether, having been formed in the liver, it was not conveyed to the muscular tissue and capable of accumulating in it. For if it be supposed that in consequence of tetanization by strychnia the amyloid substance of the liver is converted into sugar, so that the blood should become laden with it, the increased amount of sugar found in muscle might be explained simply by purely physical laws.

In order to decide this important question, whether the liver plays a part in the augmentation of the sugar in muscle which has been tetanized, there were two courses; viz. that by extirpation of the liver, and secondly, by ligature of the heart previous to tetanization. The former, which was obviously the better plan, was followed by Ranke, and he adopted it, among other reasons, because ligature of the heart and large vessels would not have removed the action of the current of lymph which might be supposed as well as the blood to convey sugar to the muscles. The result arrived at from a series of experiments upon this subject was that the liver has no influence on the increase of sugar in muscle during tetanus.

But a simpler and by far more conclusive experiment still remained in order to demonstrate that the increase of sugar in tetanized muscle was due to chemical change in the muscle itself, and not brought about either by the blood, or the liver, or the lymphatics. This consisted in examining muscle which, being cut out and quite free from blood, was tetanized by means of electricity. The details of the first experiment of this series are deserving of attention: they are as follows:

Comparative determination of sugar of muscle at rest, and tetanized by electricity, after excision:

1. *Muscle at rest.*

The flesh weighed 13·9 grammes.
The total amount of extract was 100 cc.

The result of the reduction was as follows:

(*a*) *Fluid before fermentation.*

25 cc. of watery extract of the muscle at rest reduced not completely (the fluid was already slightly coloured) 1·8 cc. of alkaline solution of copper.

100 cc. = 13·9 grammes of muscle at rest therefore reduced before fermentation 7·2 cc. of alkaline solution of copper.

100 grammes of muscle at rest therefore reduced before fermentation 51·8 cc. alkaline solution of copper.

(*b*) *After fermentation.*

25 cc. of watery extract reduced not completely (the fluid is of a reddish blue colour) 0·6 cc. of alkaline solution of copper.

2. *Tetanized Muscle.*

The flesh weighed in the fresh state 14·85 grammes.
The total amount of extract was 100 cc.

The result of the reduction was as follows:

(*a*) *Fluid before fermentation.*

25 cc. of the watery extract of the tetanized muscle reduced 3·4 cc. of alkaline copper solution.

100 cc. = 14·85 grammes of tetanized muscle therefore reduced before fermentation 13·6 cc. of alkaline solution of copper.

100 grammes of tetanized muscle reduced 91·5 cc. of alkaline solution of copper.

(*b*) *After fermentation.*

25 cc. of watery extract became of a bluish red on the addition of (the coloration is weaker than in the muscle at rest) 0·6 cc. of alkaline solution of copper.

100 grammes of muscle at rest reduced before fermentation 51·8 cc. of the alkaline solution of oxide of copper; 100 grammes of tetanized muscle on the contrary, 91·5 cc. The tetanized muscle consequently reduced more by 39·7 cc.! The reducing power of the muscle at rest being taken as 100, that of the tetanized would be 176·6.

The entire of the reduction is not to be attributed to the presence of sugar. We see that even after fermentation some reducing power remained in the liquor carnis, though its degree could no longer be accurately determined. If we assume that the 25 cc. after fermentation had actually reduced 0·6 cc. of the alkaline solution of oxide of copper, which is much too high even for the tetanized muscle, but still more so for that at rest—the fluid was indeed strongly coloured—in 100 grammes of muscle 17·2 cc. of the reducing powers of the extract of muscle would correspond to other reducing bodies than sugar; 100 grammes of muscle at rest reduced before fermentation 51·8 cc.; of this 17·2 cc. are to be deducted, leaving for the sugar 34·6 cc.; 100 grammes of tetanized muscle reduced before fermentation 91·5 cc.; after fermentation 17·2; consequently 74·3 cc. are referrible to sugar.

The result of the experiment is very plain.

Even the excised tetanized muscle shows an increase of its sugar in consequence of tetanus. The fermentation-experiment proves that the reducing matters of the muscle other than sugar are without any essential influence on the result of the reduction.

The fermentation-experiments, and the experiments made with a view to determine after fermentation the reducing powers of the extractum carnis which still remain, had all a similar result: the fluids were always coloured even by a few drops of the alkaline solution of oxide of copper, so that an accurate determination of the reducing powers was no longer practicable. Almost always, however, the tetanized muscle appeared to reduce more strongly than that at rest, which must be referred to an increase of the creatin.

Further experiments of the same kind give results analogous to the foregoing. In one instance, it was calculated that, assuming the reducing property of the muscle at rest to be equal to 100, that of the tetanized muscle would be 355:—in another the proportion was as 100 to 200.

Ranke has thus furnished a direct proof that the sugar found to exist in muscular tissue, and increased by muscular action, actually arises where it is found, and is not conveyed from the liver or elsewhere; in fact, that the sugar is formed from the muscular substance itself. Meissner's supposition is therefore fully confirmed; and Ranke has the merit of having established on a secure basis the following propositions:

1st. That there exists a true fermentable sugar in muscle.

2nd. That the amount of this sugar is increased by muscular action. (Tetanization caused by strychnine or electricity.)

3rd. That the liver has no effect in causing this increase; for the sugar is proved to arise in the muscle itself, and from the muscular substance.

NOTES ON THE OSTEOLOGY OF THE INSECTIVORA. By St George Mivart, F. L. S., *Lecturer on Comparative Anatomy at St Mary's Hospital.*

THE great interest which the order Insectivora has inspired on account of the variety of forms it contains, the exceptional characters which some of them present, their geographical distribution and geological antiquity, renders a complete investigation of the anatomy of the group peculiarly desirable.

Although the osteology of the Insectivora has been largely investigated by Cuvier[1], De Blainville[2] and others, and though the anatomy generally, of some very remarkable types, as *Petrodromus, Rhynchocyon*, and *Solenodon cubanus*, has been very carefully described by Professor Peters[3], and that of *Potomogale velox* by Professors Allman[4] and J. V. Bartoza du Borage[5]—nevertheless materials do not yet exist for a thorough and complete anatomical comparison of all the forms of the order. Amongst mammals, however, cranial and dental characters when taken together with the other main skeletal peculiarities, afford such clear indications as to affinity, and are such trustworthy guides in classification, that a careful revision of such in the various insectivorous forms (including those most recently added to the group), can hardly be devoid of a certain value. When recently at Cambridge, my friend Professor Newton was so good as to entrust me with a skin and skull of a specimen of *Ericulus nigrescens*, a form neither represented in the national osteological collection nor in that of the Royal College of Surgeons. At the British Museum, however, I have been enabled to examine the skulls or skeletons of Erinaceus, Gymnura, Centetes, Echinops, Tupaia, Ptilocercus, Rhynchocyon, Petrodromus, Macroscelides, Talpa, Scalops, Mygale pyrenaica, Urotrichus, Chrysochloris, Sorex and Galeopithecus. At the College of Surgeons I have similarly had the opportunity of studying Erinaceus, Gymnura, Centetes, Talpa, Chrysochloris, Sorex and Galeopithecus. Nevertheless a complete comparison of all the more important crania would have been impossible but for the singular kindness of Professors Peters and Allman; Professor Peters having, with the greatest liberality, forwarded to me from Berlin the precious skull of *Solenodon cubanus*, and Professor Allman having similarly transmitted to me from Edinburgh the not less valuable cranium of *Potomogale velox*.

With these materials at hand I propose to review successively the cranial and dental characters of the several genera of the order, and to add any other osteological details that I have been able to ascertain, beginning with six typical and more or less well known forms; then to state the affinities which such characters appear to me to indicate, and finally to give such distinctions between the several groups as I have been able to detect myself or to collect from the observations of my predecessors.

As, however, this paper must be published in two parts, I think it well at once to state the arrangement of the Insectivora which my observations have led me to consider the most natural. As will be seen, this classification agrees very nearly with that proposed by Professor Peters[6], differing mainly in the separation of the *Chrysochloridæ* from the *Talpidæ*, and

[1] *Leçons d'Anat. Comp.* 1837. I. and II. [2] *Ostéographie—Insectivores.*
[3] *Reise nach Mosambique*, pp. 92—110. Pl. XX—XXIV. *Abhand. der Königlichen Akad. der Wissenschaften zu Berlin.* 1864. pp. 1—22. Pl. I. to III.
[4] *Trans. Zool. Soc.* VI. pp. 1—16. Pl. I. and II.
[5] At a meeting of the Lisbon Academy on the 27th of April, 1865.
[6] *Abhand. d. k. Akad. Wissenschaften zu Berlin.* 1864. p. 20.

in the elevation of *Potomogale* into a distinct family, as was suggested by Professor Allman[1].

INSECTIVORA.

Family I. GALEOPITHECIDÆ. Galeopithecus.
II. MACROSCELIDIDÆ. Macroscelides, Petrodromus, Rhynchocyon.
III. TUPAIIDÆ. Tupaia, Ptilocercus, Hylomys.
IV. ERINACEIDÆ. Gymnura, Erinaceus.
V. CENTETIDÆ. Centetes, Ericulus, Echinops, Solenodon.
VI. POTOMOGALIDÆ. Potomogale.
VII. CHRYSOCHLORIDÆ. Chrysochloris, Calcochloris.
VIII. TALPIDÆ.
Sub-family 1. *Talpina.* Scalops, Scapanus, Condylura, Talpa.
2. *Myogalina.* Urotrichus, Myogale.
IX. SORICIDÆ. Sorex.

I. ERINACEUS[2]. In this familiar form the cranium is rather short and broad, and, as Cuvier remarks[3], when viewed from above "appears rather cylindrical than conical". It would be still more so but that it is much contracted transversely behind the orbits. The skull is broadest between the posterior roots of the zygomata, which latter are complete though somewhat slender arches. The orbits are not only incomplete behind, but there is not even any trace of a post-frontal process. Anteriorly and posteriorly the skull is more or less truncated, the occiput being nearly vertical and the anterior nares sloping gently backwards from below. A strongly projecting ridge runs upwards in front of the orbit from the anterior margin of the lachrymal foramen, in front of which its lower end forms a more or less projecting process. This ridge is more or less distinctly continued backwards over the summit of the cranium till near the posterior end of the frontal, where it meets its fellow of the opposite side, and the two unite to form a prominent sagittal ridge, which last however does not project so much as the lambdoidal one running between the posterior ends of the zygomata. The temporal fossa is exceedingly large, the face slightly concave above the anterior opening of the infraorbital canal and the summit of the cranium is also concave transversely between the orbits. The palate is rather wide and, in most cases, slightly widest between the penultimate molars. It is concave antero-posteriorly, and a slight median ridge runs in that direction for its whole length. Two large defects of ossification produce oblong openings (one on each side) for about its posterior third and the posterior border of the palate, is occupied by a strongly projecting transverse ridge situated some little distance behind the last molar. Behind this ridge is a small transverse bony plate, the outer sides of which are continuous with the outer walls of the two pterygoid fossæ, while from the middle of its posterior border a sharp point projects strongly backwards. The pterygoid fossæ are very well developed, and the outer wall of each is somewhat larger than the inner one, and is continued backwards to the auditory bulla as a ridge internal to the foramen ovale. This ridge, or ectopterygoid plate, is imperforate, there being no alisphenoid canal[4]. The mesopterygoid fossa is

[1] *Trans. Zool. Soc.* VI. p. 15.

[2] Skull well represented in De Blainville's *Ostéographie—Insectivores.* Pl. VI. For Dentition, see Pl. X. Also F. Cuvier's *Dent. des Mammifères*, No. XVI. and Owen's *Odontography*, II. Pl. CX. fig. 5.

[3] *Leçons d'Anat. Comp.* 1837. II. p. 198.

[4] For a description and definition of this canal, as also of the external alisphenoid canal, see the excellent paper by H. N. Turner, Junr., in *Pro. Zool. Soc.* 1848. pp. 64 and 65.

large, and continues of about the same breadth till it ends in a hemispherical excavation (which has no foramen in its roof) bounded by the peculiar basi-sphenoidal processes which bend outwards to complete the auditory bulla. The foramen magnum looks directly backwards, and on each side of it is a paroccipital process, anterior to which, and separated by a notch, is a true mastoid process united with the post-glenoid process of the squamosal. The glenoid surface is nearly flat, but a small entoglenoid process produces a slight transverse concavity. The cribriform plate is very large, but the pre- and basi-sphenoids are but little enlarged or swollen by internal sinuses. A venous groove traverses the inner wall of the cranium from the petrosal to the orbito-sphenoid. The premaxilla is of considerable size, and ascends beside the nasal so as (sometimes at least) to meet the anterior prolongation of the frontal. The nasals are very narrow, but remain distinct from each other: they extend backwards, on the roof of the cranium, almost as far as do the maxillæ. The parietals form a larger part of the roof of the cranium externally than do the frontals, which they considerably overlay. The malar is very small and is suspended on the outside of the zygomatic arch. The only part of the squamosal which appears on the inner wall of the cranium is a small part near that which externally articulates with the mandible. The mastoidal portion of the periotic appears largely on the outside of the skull, where it is subtriangular, with the apex upwards. It bifurcates below, the smaller portion, contributing to form the paroccipital process, the larger portion uniting with the post-glenoid process of the squamosal[1].

The mandible has its ascending ramus very concave externally, and its posterior margin, between the condyle and the angle, is very deeply concave. The horizontal ramus is very narrow behind the last molar. The inside of the ascending ramus above the mylohyoid foramen is convex. The condyle is much extended transversely, and the coronoid process does not ascend very much above it when compared to the distance of the condyle from the angle. This angle is very slightly flattened from above downwards, and inflected in a trifling degree. There is no prominence anterior to the angle developed from the inferior margin of the mandible. A single or double precondyloid foramen exists on each side, and in front of it a jugular foramen, but there is no distinct carotid foramen. There is a venous perforation in the squamosal (or between it and the parietal) immediately above the post-glenoid process. Internally it communicates with a deep groove, for a venous sinus, at the junction of the squamosal, parietal and periotic. This sinus communicates with the exterior by means of a glenoid foramen between the post and entoglenoid processes. The foramen ovale is entirely surrounded by the alisphenoid. The foramen rotundum is separated from the sphenoidal fissure by a very delicate bony lamella[2], which however may be sometimes absent. The last-mentioned fissure is of moderate size, but the optic foramen is small, and opens externally below three or four other foramina, each of which is almost or quite as large as itself. The optic foramen opens anteriorly some distance from the posterior margin of the orbito-sphenoid, while posteriorly it opens close to that margin, so that the optic nerve traverses a moderately long bony canal. Another foramen opens externally into the inner wall of the sphenoidal fissure, and is almost hidden from observation by the alisphenoidal lamella enclosing that opening. This aperture may be called the suboptic foramen; it is situated below and very slightly behind the posterior opening of the optic canal. It does not open into the cranial cavity, but into one contained in the presphenoid, and thence into the most posterior chamber of the nasal cavity. It also communicates with its fellow of the opposite side[3].

[1] As De Blainville observes, *loc. cit.* p. 37. [2] Cuvier, *loc. cit.* p. 465.

[3] This foramen, so small in *Erinaceus*, is large in *Gymnura* and also in *Petrodomus* and *Rhynchocyon*.

Another most minute foramen opens at the inner margin of the posterior opening of the optic foramen, and appears to lead to the same cavity of the presphenoid. Of the three or four foramina opening externally above the optic foramen, the two, most anterior, are orbital foramina leading to the rhinencephalic fossa just in front of its posterior boundary. The two others are venous foramina, the anterior one, opening on the frontal, is the anterior aperture of a canal running backwards and opening internally at the junction of the frontal, parietal and alisphenoid, at the anterior end of the venous groove before mentioned on the inner wall of the side of the cranium. The posterior of the two venous foramina has a similar termination behind, anteriorly it opens either in the frontal or near its margin. The posterior palatine canal is very short, below it opens by a single foramen immediately in front of the outer end of the thickened posterior transverse ridge of the palate. The spheno-palatine foramen is situated rather far backwards, and just opposite the foramen rotundum a spicule of bone passes backwards above it to the anterior margin of the lamina enclosing the sphenoidal fissure externally; so that the spheno-palatine foramen and foramen rotundum have but one common opening into the temporal fossa. There is one anterior palatine foramen on each side; it is bounded in front and within by the premaxilla, behind and externally by the maxilla. The infra-orbital foramen is single and of moderate size. It is the anterior opening of a tolerable long canal. The lachrymal foramen opens just in front of the anterior margin of the orbit. The mental foramina open near together beneath the last premolar.

The dentition appears to me to be

$$\text{I. } \frac{3-3}{2-2}, \quad \text{C. } \frac{1-1}{1-1}, \quad \text{P. M. } \frac{3-3^{1}}{2-2}, \quad \text{M. } \frac{3-3}{3-3} = \frac{20}{16} = 36.$$

In the upper jaw the first incisor is a large obtusely pointed single-fanged tooth, very widely separated from its fellow of the opposite side above, but less so below, the two converging as they descend; each is convex externally, but rather flat within. The 2nd incisor is very small, being the smallest tooth in the upper jaw; it is simple single-fanged and obtusely pointed tooth. The 3rd incisor is very close to the premaxillary suture, but, nevertheless, its single root is entirely confined to the premaxilla. It is single-fanged and single-lobed, and its crown, though larger than that of the second, is much smaller than that of the first incisor. The next tooth being the most anterior of those of the maxilla I take to be the canine. It is generally described[2] as having two roots, as it mostly has; but I have found it in some cases to have but one. Its crown is larger and more acutely pointed than in either of the posterior incisors, though it is not nearly so long as that of the first incisor. There is generally a considerable interval between the canine and the 3rd incisor. The first premolar is smaller than the canine; it has a single root and crown, but the external cingulum is more marked than in any of the preceding teeth. The 2nd premolar is still less extended vertically, but is slightly more so from within outwards. It has two or three roots. Externally the cingulum is very marked, and almost forms two extra minute cusps, one at the anterior, the other at the posterior end of the outside of the root of the crown. Internally the cingulum is so developed as to give rise to an internal low tubercle, which causes the greater transverse extent of the tooth as compared to that of the first premolar. The 3rd premolar is a very large tooth, and the difference between it and the 2nd is greater than that between any two other contiguous teeth of the upper jaw, unless it be

[1] *E. Æthiopicus Ehbg.* is said to have but two upper premolars on each side.

[2] De Blainville, *loc. cit.* p. 58, and F. Cuvier, in his *Dents des Mammifères*, Pl. XVI. fig. 1, represents it with two roots.

between the two last molars. It is tricuspidate, but the very largely-developed external cingulum almost forms a fourth tubercle behind the base of the single external cusp. This external cusp is very long and pointed. Of the two internal cusps the anterior is more developed than is the posterior, though it is not nearly so much so as is the great external cusp, which is the most vertically extended of all those of the upper molars. The first true molar is the largest tooth in the upper jaw; it is quadricuspidate with a cingulum well-marked all round, but which is very large externally, and forms a sort of fifth tubercle behind the base of the postero-external cusp. The two external cusps are of subequal vertical extent, and slightly exceed in that respect the internal cusps, the posterior of which is somewhat shorter than the anterior. When the tooth is but little worn an oblique ridge[1] may be seen connecting the postero-external with the antero-internal cusps. The 2nd true molar is similar to the first except that the tooth is smaller, that it narrows more posteriorly, the transverse diameter of its hinder part being decidedly less than that of its anterior half. The third molar is very small, with only one conspicuous cusp and a very small one anterior to the large one. The tooth is obliquely placed and laterally compressed, one surface looking forwards and inwards, the other outwards and backwards.

In the lower jaw the anterior incisor is large and very obliquely placed, convex externally and flattened within; the 2nd is the smallest tooth of the lower jaw, and, like the other incisors, is single-rooted and single-lobed. The canine has its crown much antero-posteriorly expanded, but though larger than the 2nd incisor is not nearly so large as the first. The first premolar is very small, single-rooted, but with a bilobed crown. It is but very little larger than the 2nd incisor. The 2nd premolar is a tricuspid tooth with a posterior talon, one cusp being postero-external, another postero-internal, and the third anterior. Of these the postero-external cusp is the most developed vertically, indeed decidedly more so than any other molar cusp of the lower jaw; it has also a strongly-marked talon at its base. The anterior cusp is considerably higher than the postero-internal. The first true molar bears five cusps, the anterior and the middle being connected by two ridges, and together forming a crescent with the concavity turned inwards. The two posterior cusps are connected together by a transverse ridge. The cusps are very nearly of the same height, but the two posterior are rather lower than the anterior. The 2nd true molar is similar to the first, except that it is somewhat smaller, and that the anterior cusp is less developed. The 3rd true molar is very small, almost single-cusped; and there is a greater difference of size between it and the 2nd molar than there is between any other two contiguous teeth of the lower jaw.

As regards the rest of the skeleton of *Erinaceus* it may be observed that there are 14 or 15 dorsal vertebræ, 5 or 6 lumbar, 3 or 4 sacral, and the caudal vertebræ are not numerous. The spinous process of the axis is only of moderate size; the cervical vertebræ posterior to it have short spinous processes. The cervical transverse processes are not much antero-posteriorly expanded, and the dorsal spines are short. The lumbar vertebræ have small transverse processes, metapophyses and anapophyses, but no hyperapophyses[2]. There are no hypapophysial processes. The lumbar spines are very little expanded antero-posteriorly. The manubrium is not keeled nor very prolonged. The clavicles are elongated. The scapula has the supra- and infra-spinous fossæ of subequal size. The acromion is very large, and has a large metacromion process, pointed at its extremity, not truncated. The humerus is

[1] As remarked by Professor Huxley in his (as yet unprinted) Hunterian Lectures for 1865.

[2] For a description and definition of this process (hyperapophysis), see *Pro. Zool. Soc.* 1865, p. 576, and figs. 7, 8, and 9, pp. 574 and 579.

somewhat longer than the scapula, and has generally[1] no supra-condyloid foramen, but an intercondyloid perforation. The radius and ulna are complete and distinct. The carpus is provided with a scapho-lunar bone and a small os intermedium.

The pelvis is very wide, with a very small pubic symphysis, and sometimes even with none. The ilium is not markedly concave either within or without. The femur has a strong external gluteal ridge representing a third trochanter. The tibia and fibula are anchylosed together for almost half their length, and there is a marked fossa at the lower end of their conjoined anterior surface. The metatarsus is short.

II. TALPA[2]. The second very common insectivorous genus, the Mole, has a skull which tapers from behind forwards in a remarkable degree; the cranium being exceedingly broad at its posterior part, both as compared to its anterior part, and as compared to the small vertical dimension of the skull. Its greatest breadth is situated very far back, being decidedly behind a line joining the *meati auditorii externi*, and still more posterior to one extending between the posterior ends of the zygomata, which latter are complete though exceedingly slender arches. The orbits are not only incomplete behind, but there is not even any trace of a post-frontal process, though when the skull is viewed from above there is a scarcely perceptible lateral constriction a little behind the fronto-parietal suture. The skull is truncated at neither end and the occiput slopes much forwards. There are no strongly-marked cranial ridges, but two slight undulating ones ascend from the external auditory *meati* and meet the rather more marked transverse lambdoidal one. There is no ridge or process whatever at the anterior part of the orbit. The temporal fossa is small. The palate is elongated, and between the last molar is as wide as, or slightly wider than elsewhere; it is slightly concave antero-posteriorly, but with no distinct longitudinal median ridge. There is on each side a small opening at about the anterior end of the posterior third of the palate, the extreme posterior margin of which presents a hardly noticeable thickening, situated just behind a line joining the posterior margins of the ultimate molars. There are no distinct pterygoid fossæ, the cranium being swollen at that part and presenting no ectopterygoid plate. There is also no alisphenoid canal. The mesopterygoid fossa is sharply defined, and becomes narrower transversely as it proceeds backwards, but does not end in any hemispherical or other excavation. The foramen magnum is large and looks as much downwards as backwards, the opening extending rather far forwards on the *basis cranii*. The condyles are also large, but there are no paroccipital or mastoidal projections. The glenoid surface is triangular and very small, situated immediately above the foramen ovale and rather high up; the cranial wall serving the purpose of post- and entoglenoid processes. The cribriform plate is very large, but the pre- and basisphenoids project but little into the cranial cavity. The periotic, on the other hand, is very salient, the semicircular canals being exceedingly large and conspicuous, and the cerebellar fossa relatively enormous. The cranial bones generally, especially the facial, anchylose together very early, but the premaxilla appears to be very small, and no malar is to be detected. The parietals are extensive and form the far greater part of the cranial roof not formed by the enormous supra-occipital. The last-named bone joins externally a large sub-pentagonal lamellar enlargement of the periotic, to which the name *Pterotic* has been applied by my friend Mr W. K. Parker.

[1] In a specimen of *E. Auritus*, No. 1070 a, in the British Museum, there is a distinct supra-condyloid foramen.

[2] The skeleton is well shewn in Pl. I. of De Blainville's *Ostéographie—Insectivores*. For the skull see Pl. V. For the dentition Pl. IX. Also F. Cuvier's *Dents des Mammifères*, No. XXI., and Owen's *Odontography*, Pl. CX. fig. 3.

The *meatus auditorius externus* opens far forwards and much below the glenoid surface. The mandible has its horizontal ramus long and narrow, and sometimes especially so behind the last molar. The symphysis is short. The ascending ramus has a rather small vertical and large antero-posterior dimension. The outer side of the coronoid process is decidedly concave, its inner side very slightly so. The outer side of the angle is convex, its inner side concave, especially near the interior dental foramen. The condyle is very small and very little transversely extended, yet slightly more so than antero-posteriorly. The coronoid process is obtuse and truncated at its summit; it rises above the condyle, but not to a level with the summit of the cranium. The angle projects strongly backwards, so that the posterior margin of the ramus (between the condyle and angle) is very concave. It is so far inflected that its inner surface looks slightly upwards.

There is a very small precondyloid foramen on each side; close in front of it is a jugular foramen, and about twice as far in front again is a rounded carotid foramen. A venous opening surrounds on three sides the epiotic (which is in the form of a subquadrate lamellar process of the periotic) and separates it posteriorly from the ex-occipital, superiorly from the supra-occipital, and anteriorly from the pterotic, or large pentagonal plate of the periotic before mentioned. Another venous opening is situated behind the posterior end of the zygoma, between the last-mentioned pterotic plate, the parietal and the squamosal, but there is no glenoid foramen. The foramen ovale is rather large, and situated directly beneath the glenoid surface. The foramen rotundum and sphenoidal fissure are both represented by a single opening, which is enclosed externally by a delicate lamella. There is, according to Cuvier[1], a distinct optic foramen. One orbital foramen, at least, exists on each side. A rather large posterior palatine foramen opens in the hinder margin of the palate, and is enclosed posteriorly by a *very* delicate spiculum of bone. There are also several small palatine perforations besides the two larger defects of ossification before mentioned. The spheno-palatine foramen is large and forwardly situated, namely, in front of the posterior palatine foramen and just above the last molar. There is a small anterior palatine foramen in each side. The infra-orbital foramen is enormously large, and limited above by a bar of bone as slender as the zygoma itself. The lachrymal foramen is small, and situated rather far forwards on the cheek above the ante-penultimate molar. The foramina open on the outside of the anterior half of the horizontal ramus of the mandible.

The dentition of this genus has caused much dispute, but perhaps it may be best expressed by Professor Owen's formula[2]:

$$\text{I. } \frac{3-3}{3-3},\quad \text{C. } \frac{1-1}{1-1},\quad \text{P. M. } \frac{4-4}{4-4},\quad \text{M. } \frac{3-3}{3-3} = \frac{22}{22} = 44.$$

The 3 upper incisors on each side are simple-fanged, small and rather flat-crowned; the most anterior being rather larger than the other two. The canine (if such it be) is large and conical, with two fangs. Its crown is much more vertically extended than is that of any other tooth in either jaw. It is more convex internally than externally, and it has a vertical furrow running down the anterior part of its inner surface. The three following teeth (premolars) are very small, conical, single-lobed, and double-fanged. Each has a rudimentary posterior talon, but this is most marked in the hindermost of the three. The next (4th) premolar is much larger, with three fangs. Its crown is single, conical, and pointed, and there is a marked cingulum at its base, which causes an internal prominence, and externally developes a rather large posterior talon and a faint indication

[1] *Leçons d'Anat. Comp.* II. p. 466. [2] *Odontography*, I. p. 416.

of an anterior prominence also[1]. The first upper true molar is much larger and there is a greater difference in size between it and the last premolar than between any other two contiguous grinding teeth of the upper jaw. It developes 6 pointed cusps, 3 external, 2 median, and 1 internal. The postero-median is the most vertically extended, the internal the least so, but the largest antero-posteriorly. The three outer cusps appear to be developments of the external cingulum, and the anterior is smaller than the two posterior, and sometimes might be easily overlooked. In the interspaces between these three cusps, but very near them, the two median and more vertically extended cusps descend; which latter are more widely separated from the low but anterior-posteriorly extended internal cusps, than they are from the three external. The tooth may be described as consisting of two unequal triangular prisms with an internal portion larger than either of them, the prisms (of which the anterior is much the smaller) being placed side by side, and each with a flat side turned outwards, and a cusp at each angle except the two contiguous ones, which together have but a single cusp between them (namely the median external one of the three formed by the cingulum); the larger internal portion also developing a cusp. This internal cusp is opposite the anterior of the two median cusps, so that the tooth may be said to be a tricuspid molar with three supplemental cusps developed from its external cingulum.

The 2nd true molar, slightly larger than the first one, is similarly formed, except that the three external cusps (of the cingulum) are rather more largely and more equally developed, that the two median (and normal) cusps are equally developed, and but little more so than are the three external, and that the internal part of the tooth also shows a trace of subdivision into two lobes; there being sometimes a minute posterior cusp more or less distinct from the large and antero-internal one. Thus this tooth may be said to be quadricuspidate (with the postero-internal cusp very minute) surrounded by a cingulum which developes externally three large and equal supplemental cusps. As with the preceding molar, so this may be described as consisting of two external triangular prisms and an internal part, but here the two prisms are of equal size. In the 2nd molar, as also in the 3rd, no cusp is so vertically extended as is the postero-median cusp of the first true molar. The 3rd and last true molar (the smallest of the three molars) has only two external, two median, and one internal cusp. They are small and but little extended vertically. This tooth is formed on the same type as are the other true molars; only the posterior triangular prism is all but obsolete, being only represented by the small postero-median cusp.

In the lower jaw the incisors and canines are small, simple, single-fanged teeth similar in size and form. The first premolar has two roots; it is conical, sub-triangular, with a small posterior basal talon, and is more vertically extended than any other tooth of the mandible, except the true molars: the next three teeth are similar in form but are all smaller. They increase progressively in size, from before backwards, the first of the three (i.e. the 2nd premolar) being the smallest grinding tooth in the lower jaw. The 1st true molar is quinquecuspid, there being two external and three internal cusps. Of these the external are rather more vertically extended than are the internal, and of the two external the more anterior is slightly the higher. The tooth may be described as consisting of two triangular prisms placed side by side, each with a flat face inwards, and an angle outwards; therefore placed in a reversed position as compared to the triangular prisms of the uppper true molars. The 2nd inferior molar is similarly formed to the first, except that it is slightly larger, that the three

[1] As well shewn in De Blainville's *Insectivores*, Pl. IX, and in F. Cuvier's *Dents des Mammifères*, Pl. XXIII. fig. 1.

internal cusps are slightly higher, and that the antero-external cusp predominates more in vertical extent as compared to the postero-external. The 3rd is the smallest of the three inferior molars. It is formed on the same type as the others, differing only in the smaller development of the posterior of its two prisms, and of the antero-internal cusp.

As regards the rest of the skeleton of *Talpa*, there are 13 dorsal and 5 lumbar vertebræ, or according to De Blainville[1], 14 dorsal and 6 lumbar, and 4 or 5 sacral vertebræ. The spinous process of the axis is considerable, and there is a minute one in the first, and another on the 3rd cervical vertebræ, but the other cervicals are without such, and their neural arches are very narrow antero-posteriorly. The transverse processes of the fourth fifth and sixth overlap each other, as Prof. Owen[2] remarks; there are no cervical hypapophyses. The dorsal vertebræ, except the last 3 or 4, are also almost destitute of spinous processes, but they have strongly developed forwardly projecting lateral processes which appear to answer to both the metapophyses and transverse processes of the lumbar vertebræ, where the former of these processes are rather largely developed, and the transverse and spinous processes moderately so; hyperapophyses are absent. The 4th lumbar vertebra has sometimes a crest-like hypapophysis, and, as Prof. Owen has remarked[3], antigenous hypapophysial ossicles are interposed beneath the interspaces of the bodies of the lumbar vertebræ. The manubrium is enormous and strongly keeled, and the clavicle, as is well known, is extraordinarily short and stout, and articulates with the remarkably short and ridged humerus, which has its inner condyle perforated. The radius and ulna are both complete and distinct, the carpus has an *intermedium*, and an elongated curved sickle-shaped extra ossicle. The ultimate phalanges of the manus are much longer than the others, and bifurcate at their extremity; the scapula has an extraordinarily elongated and narrow form, and is longer than the humerus. The acromion is very short with no metacromion process.

The pelvis, as is well known, is extraordinarily long and narrow and without a symphysis; the confluent spines of the sacrum form a lofty crest. The ilium is very narrow. The short femur has almost a distinct third trochanter. The tibia and fibula are confluent for the lower and greater part of their extent. The metatarsals are shorter than the tarsus or pedal digits. The shoulder girdle is situated singularly forwards, obscuring the neck.

III. SOREX[4]. The third well-known insectivorous family, that of the Shrews, presents us with the following conditions. The cranium tapers anteriorly and more approximates in general outline to that of *Talpa* than to that of *Erinaceus*. It is broadest some distance behind the glenoid surfaces. As is well known, there is no zygoma, nor is the orbit limited off from the temporal fossa by any rudiment of a post-frontal process. The skull is truncated at neither end, and, in spite of the sometimes strongly projecting lambdoidal ridge, the occiput slopes strongly forwards. No ridge or process is developed in front of the orbit, but there is sometimes a rather marked sagittal crest. The palate is rather narrower than in *Talpa*, and sometimes it becomes narrow posteriorily and projects considerably beyond the last molar. It has no defects of ossification, nor any median ridge, and rarely any posterior one. There is no pterygoid fossa,

[1] *Loc. cit.* p. 7.

[2] *Anatomy of Vertebrates*, II. p. 386, and *Reports of British Association*, 1861 and *Ed. Phil. Journal*, 1861, p. 298.

[3] British Association, 1861.

[4] For a representation of the skeleton, see De Blainville, *loc. cit.* Pl. II., for the skull, Pl. V., and for the dentition, Pl. X. Also F. Cuvier, *loc. cit.* No. XX., and Owen, *loc. cit.* Pl. CX. fig. 4.

and the meso-pterygoid, which continues of about the same breadth backwards, ends in no median excavation. A large and peculiar defect of ossification exists, as is well known, on each side of the *basis cranii*, behind the enormous post-ento-glenoid processes. The foramen magnum, as in *Talpa*, looks almost as much downwards as backwards. There is no paroccipital process, but a more or less marked mastoidal (?) projection. The glenoid surface, as in *Talpa*, is much more anteriorly situated than in *Erinaceus*, and looks forwards from the great development of the post-ento-glenoid process. The premaxillæ, according to the researches of Dr Ed. Brandt[1], are of large size, giving rise to 4, 6 or 8 incisor teeth. The facial bones, including the nasals, early anchylose together. The supra-occipital is very large. The mandible has much the form of that of *Talpa*, except that the horizontal ramus is much shorter. The external surface of the ascending ramus is less concave, however, while its internal surface, is very much more so, presenting a very large and singularly deep excavation, quite characteristic of the genus. The condyle is very peculiar, the greater part of its articular surface being situated somewhat inferiorly and looking backwards (for the post-glenoid process) instead of upwards. The angle is very attenuated and elongated. The foramen rotundum appears to be replaced by an enlargement of the sphenoidal fissure. There is a foramen placed just within the post-ento-glenoid process. This is said by Cuvier[2] to be the foramen ovale. Another smaller foramen is placed a little nearer to the middle line of the *basis cranii*. The infra-orbital foramen is of considerable size and limited posteriorly by a thick bar of bone. The dentition of the genus is very characteristic, and appears to consist of I. $\frac{3-3}{1-1}$ or $\frac{4-4}{1-1}$ or $\frac{2-2}{1-1}$, C. $\frac{1-1}{1-1}$, P. M. $\frac{2-2}{1-1}$ or $\frac{1-1}{1-1}$, M. $\frac{3-3}{3-3}$. The first incisor is much larger than the others, and has always two cusps. The other incisors become successively smaller, and the canine is always smaller than the smallest. When there are two upper premolars the first is very simple and is the smallest tooth in either jaw. The second, or—when there is but one on each side—the only, premolar is a very large tooth with three or four fangs, all the preceding teeth being single-rooted. There is a greater difference in size between it and the preceding tooth than there is between any other contiguous teeth in the whole dentition. It consists of one large external cusp (the most vertically extended one of all the molars) supplemented by two minute ones, one anterior, the other posterior. It has also a considerable projection inwards, but this scarcely gives rise to a distinct cusp. This tooth has a certain resemblance to the corresponding one of *Talpa*, but it is much larger in all dimensions; the anterior supplementary cusp is very much more marked, as also the internal projection. Such is its condition in *S. murinus*, but in some others, e.g. *S. fodiens*, it is still larger relatively, and consists of three external cusps (the middle one of which predominates but little over the others), while the internal production of the tooth gives rise to two low prominences.

The first upper true molar developes seven pointed cusps—3 external, 2 median, and two internal. The postero-median is the most vertically extended, the postero-internal the least so. The three outer cusps are doubtless developments of the external cingulum, and are subequal in size, or else the median rather predominates. The tooth is formed on the same type as the corresponding one of *Talpa*, only the external and median cusps are more equal in size and the internal part of the tooth is larger. It may similarly be described as consisting of two more or less unequal

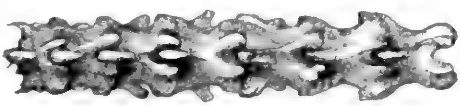
[1] Изслѣдованія о зубной системѣ куторъ или землероекъ.—1865.

[2] *Loc. cit.* Vol. II.

triangular prisms placed on a base which has an internal bicuspidate projection larger than either of them; the prisms (the anterior of which is slightly or decidedly the smaller) being placed side by side, and each having a flat side turned outwards. There is, as in *Talpa*, a cusp at each angle except the two contiguous ones, which together have but a single cusp between them (namely the median external one); the large internal portion of the tooth also developing a large anterior cusp and a small posterior prominence. The 2nd true molar, of about the same size as the first, is similarly formed except that each of the two contiguous angles of the prisms develops a minute cusp, so that there are 4 external, 2 median, and 2 internal. It differs from the corresponding tooth of *Talpa* in the greater equality between the external and median cusps and the greater size of the internal part of the molar. The last upper grinder is the smaller of the three true molars, and there is a greater difference between it and its predecessor than is the case in *Talpa*. In form it closely resembles its homologue in the last-named genus, and consists of the external and 2 median cusps and an internal prominence—the posterior prism being all but obsolete and only represented by the small postero-median cusp.

In the lower jaw there is, as is known, one very elongated pointed incisor on each side, which sometimes has several cusps or denticulations. The canine is a small conical tooth, the smallest of the lower jaw. The premolar is somewhat larger, but simple and conical, with a very small posterior talon. The first true molar is quinquecuspid, there being 2 external and 3 internal cusps. Of these the external are more extended vertically than are the internal; and of the two external the anterior is considerably the higher (predominating more than in *Talpa*), and in some (e. g. *S. fodiens*) the tooth consists of two triangular prisms placed side by side, each with a flat face inwards and an angle outwards. In *S. murinus*, however, this tooth very closely resembles the corresponding one of *Erinaceus*, the three anterior cusps, with their connecting ridges, forming a crescent with the concavity turned inwards, while the posterior cusps are connected by a transverse ridge. The 2nd inferior molar in size and form closely resembles the first. The 3rd is the smallest of the three inferior molars, but is similar in form to the others, except the very small size of its posterior part, which aborts more than in *Talpa*, though not as in *Erinaceus*.

As regards the rest of the skeleton of *Sorex*, there are from 13 to 15 dorsal, 5 or 6 lumbar, and 4 or 5 sacral vertebræ. The axis has a moderately large spinous process, but the other cervical vertebræ are either without such or have only very small ones. Their neural arches are generally very narrow antero-posteriorly, though in *S. murinus* this is not the case. As *De Blainville* has remarked[1], there are very large and characteristic cervical hypapophyses. The transverse processes of the cervical vertebræ overlap each other considerably, but not as in *Talpa*. The dorsal vertebræ have sometimes small low spinous processes, but often many of the anterior ones have none. They have however strongly developed, forwardly projecting lateral processes, well seen in *S. murinus*. The lumbar vertebræ are destitute of the small hypapophysial ossicles and large meta-



7 trunk vertebræ of Sorex. 2 natural size.

pophysial processes of *Talpa*. On the other hand, they have small anapophyses and transverse processes and very well marked hyperapophyses.

[1] *Loc. cit.* p. 23.

The manubrium is more or less large and T shaped, but not keeled. The clavicle is small and slender, and does not articulate with the humerus. The scapula is short and broad compared to that of *Talpa*. Often there is a large spine, but absolutely no supra-spinous lamina. In *S. murinus*, however, the latter is large, and there is a large metacromion process as well as the normal acromion, the process appearing to bifurcate peculiarly. The humerus is sometimes longer, sometimes a little shorter than the scapula. It is not cylindrical, but much ridged. Its inner angle is generally perforated through; in *S. murinus* it is not so. The radius and ulna are complete and distinct, the carpus has a scapho-lunar bone, but no os intermedium[1], and no sickle-shaped ossicle, and the ultimate phalanges do not bifurcate, and are shorter than the proximal ones. The pelvis is long and narrow, and instead of a symphysis it is widely open below. The femur has a third trochanter, and the tibia and fibula are confluent for the lower half of their extent.

IV. Tupaia[2]. The skull of this Asiatic genus has a very different aspect from that of any of the three common forms already noticed, tapering anteriorly, as it does, both vertically and transversely more than in any of them. The skull is broadest between the posterior roots of the zygomata (which are complete though slender arches), and its roof is but little narrowed between the orbits,—the attenuation being confined to the muzzle. The orbits are large and completely encircled by bone, a long and slender post-orbital process of the frontal descending to join the malar. The skull is truncated neither anteriorly nor posteriorly, the occiput sloping upwards and backwards, as also the anterior nares. There is no distinct ridge in front of the orbit, but the anterior margin of the latter is sharply prominent, and towards its lower end a process projects backwards immediately above the lachrymal foramen. From the post-orbital process a ridge extends backwards and inwards over the cranium till it meets its fellow of the opposite side, when the two unite to form a short sagittal ridge, which joins the more prominent lambdoidal one extending between the posterior roots of the zygomata. The temporal fossa is exceedingly small, and no noticeable depression marks the sides or summit of the face or cranium proper, and the middle of the dorsum of the muzzle is convex transversely. The palate is long and narrow, but widest between the last molars. It is slightly concave antero-posteriorly, and has no median ridge or posterior thickened border. The hinder margin is slightly concave, and may extend about as much backwards beyond the last molar as the antero-posterior diameter of that tooth, or it may be on a line with its hinder end. Small irregular defects of ossification mark the posterior third of the palate. The pterygoid fossa is very peculiar; it is very small and situated much behind the posterior margin of the palate, which it does not approach by reason of the short and peculiar ecto-pterygoid plate, which is a very small and pointed process projecting downwards, backwards and outwards, immediately beneath the foramen rotundum. This plate is only perforated by an external ali-sphenoidal canal[3] which traverses its root. The meso-pterygoid fossa is very wide, but becomes slightly narrower as it proceeds backwards. It ends posteriorly in no excavation, but its roof is continued onwards uninterruptedly into the posterior part of the *basis cranii*. No processes of the basi-sphenoid appear to contribute and form the auditory bullæ, which are smooth, completely ossified prominences. The foramen magnum looks almost as much downwards as backwards;

[1] According to De Blainville, *loc. cit.* p. 25.

[2] The skeleton is represented by De Blainville, *loc. cit.* Pl. III. For the skull see the same, Pl. VI. For the dentition the same, Pl. X. Also F. Cuvier, *loc. cit.* No. XVII., and Owen, *loc. cit.* Pl. CXI. fig. 3.

[3] For an account of this canal, see *Pro. Zool. Soc.* 1848, p. 65.

there is no paroccipital process, and but a rudiment of a mastoidal one. The glenoid surface is nearly flat, and there is but a very small rudiment of a post-glenoid process, the *meatus auditorius externus* serving to limit that surface posteriorly, and the projecting auditory bulla forming its internal limit. The premaxilla is of moderate size, but is separated from the frontal by a considerable interval. The nasals remain distinct, about as long as the other facial bones, but all the bones of the skull appear to anchylose together with tolerable rapidity. The nasals extend backwards, on the upper surface of the skull, about as far as do the maxillæ. The malar has a large perforation. The mandible has a long and very low horizontal ramus. The coronoid process is well developed, and rises considerably above the condyle, which is much extended transversely. The angle is small and projects downwards before curving upwards, so that the outline of the hinder part of the inferior margin of the mandible is concave. The angle is very slightly inflected, its inner surface being concave and looking slightly upwards.

There is a small carotid (?) foramen at the margin of the auditory bulla, immediately opposite the middle of the occipital condyle, also a small glenoid foramen. The foramen ovale is represented by a narrow opening at the anterior margin of the auditory bulla, and widely separated from the sphenoidal fissure, which latter is distinctly separated from the foramen rotundum. The optic foramen is very large, and separated from the sphenoidal fissure (which is quite or almost equal to the former in size), only by a very delicate spiculum of bone, and there is no sub-optic foramen. As has been said, there is a large malar foramen, also an external alisphenoidal canal traverses the root of the ecto-pterygoid process. The external opening of the *meatus auditorius externus* looks mainly outwards, and is not separated by the glenoid foramen from the posterior root of the zygoma. There is a distinct supra-orbital foramen, the infra-orbital one is small and opens externally at the anterior end of a more or less long canal. The spheno-palatine foramen is situated far forwards above, but internal to, the penultimate molar. The lachrymal foramen opens at the anterior margin of the orbit, and rather without than within it. There is a large posterior palatine foramen and a considerable anterior palatine one. Two dental foramina open beneath the first and second inferior premolars.

The dentition is $\text{I.}\ \frac{2-2}{3-3},\ \text{C.}\ \frac{1-1}{1-1},\ \text{P.M.}\ \frac{3-3}{3-3},\ \text{M.}\ \frac{3-3}{3-3} = \frac{18}{20} = 38.$

In the upper jaw, the first incisor is of moderate size, conical, curved, and separated by an interval from its fellow of the opposite side, the two converging very slightly as they descend. The 2nd upper incisor is of about the same size as the first[1] and of similar shape, but is separated from it by a considerable interval. The canine appears externally at some little distance behind the pre-maxillary suture, and is separated from the second incisor by an interval about twice as great as that which divides the latter from the first incisor. The first premolar is shorter than the canine, and, unlike the latter, has two roots. Its crown is simple and conical, but there is a trace of a posterior talon.

The 2nd and 3rd premolars are the most vertically extended grinding teeth of the upper jaw. They each consist of one long conical cusp surrounded by a cingulum, which externally gives rise to one small prominence (or cusp) in front of, and another behind the principal cusp, and internally developes another, which however (as well as the small external cusps) is more marked in the 3rd than in the 2nd premolar.

[1] The anterior incisor is rather large, and decidedly larger than the posterior one in *T. ruficaudata*, judging from the skull in the British Museum, No. 1450, and 48, 1, 27, 14, which was extracted from the stuffed skin, No. 47, 7, 8, 13.

The 1st molar[1] may be said to present 8 cusps[2], 4 external, 2 median, and 2 internal. The 2 median cusps appear to answer to the single one of the premolars, the 4 external are very small (especially the middle two), and are developments of the external part of the cingulum, while its internal part (much larger here than in the premolars) appears to give rise to the two internal cusps, the posterior of which is very small. The largest of all these cusps is the antero-internal; the postero-median is slightly more extended vertically than is the antero-median. Thus, this tooth has a considerable resemblance to the corresponding tooth of *Talpa*, and may be also described as consisting of two unequal triangular prisms, with an internal portion larger than either of them; the prisms (of which the anterior is the smaller) being placed side by side, and each with a flat side turned outwards and a cusp at each angle. The 2nd molar resembles the 1st, except that the prisms are of almost equal size, and that generally the postero-internal cusp is still more rudimentary. The 3rd and last molar is much smaller, and, as in *Talpa*, consists (when unworn) of 2 external, 2 median, and 1 internal cusp, the tooth being formed on the same type as the true molars; the posterior prism, however, being all but obsolete, and only represented by the postero-median cusp.

In the lower jaw the 1st incisor is in contact with its fellow of the opposite side, and the 2nd joins the 1st. These teeth are long, slender, of equal length, and procumbent like those of Lemurs, and the 2nd much resembles the lower incisors of the *Indrisinæ*[3]. The 3rd is slightly separated from the 2nd, and only about half the length of the latter. The canine is much larger, is conical, curved, and with the point directed upwards. There is a small interval between it and the 3rd incisor. The 1st premolar is small, simple, conical, pointed, and slightly curved, however, with a trace of a posterior talon. It is generally separated from the canine by a rather long interval. The 2nd premolar is larger and sub-triangular, consisting of one large cusp, with one very small additional one at its base behind, and another in front. The 3rd premolar closely resembles the single lower premolar of *Erinaceus*, and is a tricuspid tooth, one cusp being postero-external, another postero-internal, and a third anterior. Of these the postero-external cusp is the most developed vertically, but, unlike *Erinaceus*, the postero-internal cusp is considerably higher than the anterior, and bears the strongly marked talon at its base. The 1st and 2nd molars are quite like those of *Erinaceus* before described[4], except that the postero-internal cusp is sometimes divided into two, and is not connected with the postero-external one by so well-developed a ridge. The 3rd and last lower molar (unlike that of *Erinaceus*) completely resembles the 2nd molar, except that it is of smaller size, and thus approximates to its condition in *Talpa*.

As regards the rest of the skeleton of *Tupaia*, it may be observed that there are 13 dorsal, 5 or 6 lumbar[5], 3 sacral, and many caudal vertebræ.

The spinous process of the axis is moderate, and the other cervical vertebræ (except the atlas) have exceedingly small spinous processes. The cervical transverse processes are not much antero-posteriorly expanded. The dorsal and lumbar vertebræ have only moderate spines, each of the lumbar ones being very much bent forwards over the vertebra next in front of it. The lumbar transverse processes are long but not much antero-posteriorly developed.

Metapophyses are rather well developed, and distinctly traceable forwards to the 3rd dorsal vertebra. Anapophyses are also well developed in

[1] I have ascertained that the third premolar succeeds a deciduous tooth formed like the true molars, of which consequently there can be but three.

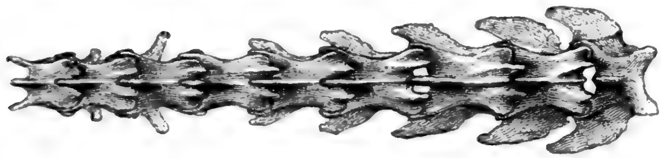
[2] The two median external cusps are very minute, and soon disappear with use.

[3] See *Pro. Zool. Soc.* 1866, p. 157.

[4] See antea, p. 285.

[5] De Blainville says 13 dorsal, 7 lumbar, and 4 sacral, *Loc. cit.* p. 31.

the lumbar region, and can be traced forwards to the fifth dorsal; hyperapophyses are very marked (see fig. 2) from the last dorsal vertebra to the



9 trunk vertebræ of *Tupaia*. Scale, $1\frac{1}{2}$ natural size.

fifth lumbar inclusive; and there are indications of this process on the neural arches of the 3rd and 4th cervical vertebræ. There are neither antogenous nor exogenous hypapophysial processes beneath the trunk or cervical vertebræ.

The clavicles are long and rather slender. The manubrium is of moderate size and not keeled. The scapula has well-developed supra- and infra-spinous fossæ, an anterior margin which is very convex, the convexity continuing down to its glenoidal end, but only a rudiment of a metacromion process. The humerus is much longer than the scapula, its internal condyle is perforated, but not the olecranal fossa. The radius and ulna are complete and distinct.

The carpus is provided with an *os intermedium* and a scapho-lunar bone.

The pelvis is of moderate size, with a rather elongated pubic symphysis. The ilium is markedly concave externally. The femur has a strong guteal ridge, which below expands into a third trochanter. The tibia and fibula are perfectly distinct for their whole length. The metatarsus is but very little longer than the tarsus or than the posterior digits.

V. MACROSCELIDES. In this African form[1] the skull (when not inflated by large air-cavities as in *M. proboscideus*) presents a certain resemblance in general shape to that of some species of *Tupaia*, though the snout is never so attenuated as in *T. tana*. The skull is broadest between the posterior roots of the zygomata (which are complete, and, compared to those of *Tupaia*, rather broad vertically), and its roof is very much narrowed between the orbits, which are widely open posteriorly, there being no trace even of a post-orbital process. The anterior nares are rather vertical, and the plane of the foramen magnum is more so than in *Tupaia*. The anterior margin of the orbit is sharply prominent, and there is an *os orbitale anterius*[2], but there is no projecting process towards the lower end of that cavity. Cranial ridges, similar in form and direction to those of the last-named genus, are sometimes slightly marked. The temporal fossa is exceedingly small, and on each side of the muzzle in front of the orbit there is a more or less marked concavity, and a groove runs antero-posteriorly along the middle of the dorsum of the muzzle. The palate is rather wide posteriorly, most so between the last molars. It is very slightly, if at all, concave antero-posteriorly, and has no median ridge or thickening at the posterior margin, which appears to be convex[3] (?) and to extend back beyond the last molars. Large defects of ossification (sometimes three large pairs besides smaller ones) exist on the palate. Small pterygoid fossæ, unlike those of *Tupaia*, extend forwards to the posterior margin of the

[1] For the entire skeleton, the skull, and dentition, see De Blainville, *loc. cit.* Pls. III. V. and X.

[2] Peters, *Reise nach Mosambique*, p. 95.

[3] Peters, Table XXII. fig. 14.

palate; the ecto-pterygoid being a more or less elongated lamella (not a narrow process), which does not appear[1] to be perforated by either an internal or an external alisphenoidal canal. The meso-pterygoid fossa is narrow throughout, does not become narrower from before backwards, and ends in no posterior excavation. Very large auditory bullæ occupy the posterior part of the *basis cranii*. As in *Tupaia* there is no paroccipital process, and no marked mastoidal one, though the mastoidal region is sometimes very enlarged and inflated. The *foramen magnum* looks mainly backwards, the glenoid surface is nearly flat, and there is only the smallest possible rudiment of a post-glenoid process. The auditory bulla limits it internally, but the *meatus auditorius externus* is more or less separated from it behind. The premaxilla is of moderate size, and though considerably prolonged up (as a very narrow process beside the nasals), it does not nearly join the frontal. Its posterior margin (the premaxillary suture) runs at first somewhat backwards as it ascends from the alveolar margin. The nasals remain distinct, but do not extend backwards, on the upper surface of the skull, so far as do the maxillæ. The malar has no perforation, but a marked excavation for muscular attachment.

The mandible has a moderately high horizontal ramus, its ascending one has a very slender coronoid process, which rises but very slightly, if at all, above the small and but little transversely extended condyle. The angle is long and pointed, but only projects very slightly downwards, and is not in the least inflected.

There is a small carotid foramen near the margin of the auditory bulla (immediately opposite the middle of the occipital condyle), also a glenoid foramen immediately in front of and above the *meatus auditorius externus*.

The foramen ovale appears to be in the form of a rather large, rounded aperture just in front of the auditory bulla, and separated from the sphenoidal fissure by only a very narrow bony lamella. One single opening represents both the foramen rotundum and the last-named opening.

The optic foramen is large and very slightly separated from the sphenoidal fissure, which it almost, if not quite, equals in size. Besides these there is another and smaller foramen immediately beneath the optic, which does not lead into the cranial cavity, but communicates with its fellow of the opposite side, the suboptic foramen. As has been said, there is no malar perforation or any internal or external alisphenoidal canal. The *meatus auditorius externus* has a very large external opening which looks mainly backwards, and is more or less separated from the glenoid surface by the glenoid foramen. There is no supra-orbital foramen, but the single and relatively considerable infra-orbital one opens externally at the anterior end of a very short canal. The spheno-palatine foramen is small and situated much as in *Tupaia*. The lachrymal foramen opens well within the orbit, immediately above the posterior aperture of the infra-orbital canal. There is a large posterior-palatine foramen and a considerable anterior-palatine on each side. A mental foramen opens beneath the antepenultimate molar.

The dentition is $\text{I. } \frac{3-3}{3-3},\ \text{C. } \frac{1-1}{1-1},\ \text{P.M. } \frac{3-3}{3-3},\ \text{M. } \frac{3-3}{3-3} = \frac{20}{20} = 40$[2].

In the upper jaw the 1st incisor is a more or less pointed, slightly conical tooth, separated by an interval, as in *Tupaia*, from its fellow of the opposite, but the two can scarcely be said to converge at all as they descend. The 2nd incisor is slightly smaller than the first, and shews more or less inclination to form a bilobed crown; it is generally separated from it by a

[1] i. e. as far as can be judged from the mutilated crania in the British Museum.

[2] According to Dr Peters, *loc. cit.* p. 88, the number of grinders is sometimes seven above and eight below on each side. I have found the additional grinder in the specimen of *M. brachyrhynchus* in the British Museum.

slight interval. The 3rd incisor is generally (as in *M. intufi*, *M. rupestris* and *M. brachyrhynchus*, but not in *M. proboscideus*) larger than the second, but very similar in form. In *M. proboscideus* it joins the second incisor, but in *M. intufi* it is separated from it by a considerable interval. It appears to have but one root. The canine is always at some little distance behind the third incisor. It is a laterally compressed tooth, scarcely, if at all, larger than the third incisor, with two roots and also two cusps, the anterior of which is much the larger.

The first premolar is sometimes (e. g. in *M. proboscideus*) small, exceedingly like the canine in size and form, sometimes (e.g. in *M. intufi*) its posterior half is more expanded laterally. The second premolar is much larger; and there is greater difference in size between it and the first premolar than between any other two contiguous grinding teeth in the upper jaw. It is generally quadricuspidate, with a small posterior talon and an oblique ridge running from the postero-internal to the antero-external cusp, and the two external cusps being much more vertically extended than the two internal ones. Sometimes, however, as in *M. rupestris*[1], there are but two cusps, the posterior giving off a small process inwards at its base. The third premolar is quadricuspidate with an oblique ridge running from the postero-internal to the antero-external cusp, and with a smaller posterior talon, which in *M. proboscideus* causes the postero-external cusp to appear double. The upper premolars are not more extended vertically than the molars. The first true molar is a quadrate tooth with a deep vertical groove on the middle of its external surface and another on the middle of its internal surface. It is quadricuspidate, the two external cusps being

Left dental series of upper jaw of *Macroscelides*. Scale, 2 natural size.

more vertically extended than the two internal. Before being worn by use the antero-external cusp is connected with the antero-internal by a transverse ridge, and the two posterior cusps are similarly connected; so that each tooth consists of two crescents with the convexity of each forwards; a structure altogether different from anything we have yet seen. The 2nd molar is quite similar to the first, and these two teeth are the largest of the upper jaw. The 3rd molar is smaller, and consists of but three cusps. An anterior pair united by a transverse ridge (like those of the other molars), and a posterior portion which is undivided.

In the lower jaw the first incisor all but, or quite, joins its fellow of the opposite side. It joins the second incisor, and indeed all the teeth of each ramus are in contact with each other. The inferior incisors are very different from those of *Tupaia*, being short, with the crowns widening antero-posteriorly, as they emerge from the alveoli. The 2nd and 3rd incisors seem to have their crowns more or less trilobed, and the anterior margin of each passes a little to the outside of the posterior margin of the incisor next in front. The canine is similar to the incisors, but rather smaller. The first premolar is rather more expanded antero-posteriorly, and shews a tendency to trilobation. The 2nd premolar is distinctly trilobed, the median lobe being the largest. The 3rd premolar is similar to the second, only somewhat larger. The first true molar is quinquecuspidate, there being 2 posterior, 2 median cusps, and 1 anterior one; ridges connect together the two posterior and the two median cusps, and also the

[1] 59. 5. 7. 12 in the British Museum.

postero-external, and antero-median, and the antero-external and the anterior cusps. So that the tooth may be said to consist of two triangular prisms placed obliquely side by side; one side of each looking forwards and inwards, and one angle backwards and outwards. The 2nd and 3rd molars are similarly formed, except that the anterior cusp is almost obsolete in the second molar and quite so in the third one. As Dr Peters has observed[1], there is sometimes a small tooth behind the third molar.

As regards the rest of the skeleton of *Macroscelides*, there are 13 dorsal[2], 6 or 7 lumbar (together 19 or 20), 3 sacral, and many caudal vertebræ. The spinous process of the axis appears to be rather larger relatively than in *Tupaia.* The other cervical vertebræ have no spinous processes or they are in a very rudimentary condition. The cervical transverse processes are but little antero-posteriorly expanded. The dorsal spines are very elongated, as also the lumbar ones, and both are more or less antero-posteriorly expanded at their summits. The lumbar spinous processes are not bent forwards to such an extreme degree as in *Tupaia.* The lumbar transverse processes are elongated and considerably expanded in the antero-posterior direction. Metapophyses are largely developed, but the anapophyses are rather small, and there are no hyperapophyses. On the other hand, there are antero-posteriorly directed hypapophysial ridges beneath the anterior lumbar vertebræ.

The clavicles are long and rather slender. The manubrium is of moderate size and not keeled. The scapula has well developed supra- and infra-spinous fossæ, and an anterior margin which is very convex, but the convexity is not continued down to its glenoidal end, the lower half of the anterior margin being rather concave. There is a long metacromion process. The humerus is much longer than the scapula, its internal condyle is perforated, also the olecranal fossa. Unlike *Tupaia*, the ulna is imperfect, becoming very attenuated at the middle of the fore-arm and uniting with the radius. The carpus is provided, no doubt, with separate scaphoid and semilunar bones as well as an *os intermedium*, though I have not been able to distinguish them with certainty. The pelvis is of moderate size, with a rather elongated symphysis. The ilium has scarcely any external concavity. The femur has so strong a gluteal ridge as to form a third trochanter. The tibia and fibula anchylose together above the middle of the leg. The metatarsus is very much longer than either the tarsus or the posterior digits.

VI. CENTETES. The skull of this large insectivore[3], from Madagascar, when viewed above, is far more cylindrical than is the cranium of any form yet examined. It is broadest between the glenoidal surfaces, and thence tapers forwards in a regular but exceedingly slight degree. The orbits are not only incomplete behind, but there is not even any trace of a post-frontal process. Posteriorly the skull is truncated, but anteriorly the nares slope gently backwards. There is neither a ridge nor any projecting process at the front of the orbit. The sagittal crest begins to be developed at the posterior end of the nasals, and runs thence backwards to the remarkably projecting lambdoidal ridge which extends between the glenoid surfaces. The temporal fossa is large, and there is a concavity above and in front of the first upper premolar, but none above the anterior opening of the infra-orbital canal or on the summit of the cranium between the orbits. The palate

[1] *Loc. cit.* p. 88. This additional last grinder may be but an individual variation. See note p. 626 of *Pro. Zool. Soc.* for 1864.

[2] Dr Peters and M. de Blainville both assign 13 dorsal and 7 lumbar vertebræ to this genus, but in a specimen of *M. intufi* in the British Museum there are but 19 trunk vertebræ.

[3] The skeleton is represented by De Blainville, *loc. cit.* Pl. IV., the skull at Pl. VI., the dentition at Pl. X. For the latter see also F. Cuvier, *loc. cit.* No. XIX., and Owen, *loc. cit.* Pl. CX. fig. 6.

is long and narrow, but of singularly equal width, narrowing but little forwards. It is scarcely concave antero-posteriorly, and has no median ridge running in that direction, nor any defects of ossification. The posterior margin of the palate is thickened (without any transverse bone-plate behind it), and the thickening is concave backwards without any median projection. It projects back some little distance beyond the last molar.

Pterygoid fossa cannot be said to exist, the ecto-pterygoid ridge not developing into a descending plate of bone, although distinctly perforated posteriorly. The meso-pterygoid fossa slightly narrows as it proceeds backwards, and ends in a hemispherical excavation (with a foramen in its roof), bounded by the basi-sphenoidal processes, which bend outwards to complete the auditory bullæ. The foramen magnum looks directly backwards, and on each side of it is a well-developed paroccipital process, anterior to which, and separated from it by a notch, is a true mastoid process, united with the prominent process of the squamosal, so that there are but two processes here on each side. The mastoid contributes to form both the paroccipital and squamosal process, but rather more of it goes to the latter than to the former.

The glenoid surface is made transversely concave by a strongly projecting ento-glenoid process. The rhinencephalic chamber is smaller than in *Erinaceus*, and the presphenoid is swollen by a large internal cavity. The premaxilla is rather small, and sometimes meets the anterior prolongation of the frontal, but sometimes does not do so. The nasals unite early together, the separation continuing longest at their anterior end. They extend backwards on the roof of the cranium, almost as far as do the maxillæ. The parietals form more and the frontals less, of the roof of the cranium than in *Erinaceus*. The zygoma is wanting, only a small process extending backwards and outwards above the last molar. The squamosal is all but entirely excluded from the cranial cravity. The mastoidal portion of the periotic appears largely on the outside of the skull, where it is sub-triangular with the apex upwards; it divides below, as has been said.

The mandible has its ascending ramus only very slightly concave externally, its posterior margin between the condyle and the angle is short and not very concave. The horizontal ramus is not constricted behind the last molar. The inside of the ascending ramus above the inferior dental foramen is very deeply concave. The condyle is rounded, not transversely extended, and the broad coronoid process ascends much above it when compared to the distance of the condyle from the angle. This angle is small and much flattened above and below, having an appearance reminding us of its condition in Marsupials. There is another obtuse prominence at the inferior margin of the mandible, more or less marked, and projecting downwards some distance in front of the angle.

There is a rather large precondyloid foramen on each side, and in front of it a jugular foramen, but I have not observed a carotid foramen. There is a venous opening in the parietal, near the margin of the squamosal; also a glenoid foramen immediately behind the glenoid surface. The foramen ovale is formed entirely by the alisphenoid and one opening represents both the foramen rotundum and the sphenoidal fissure. The optic foramen is very small, and with the last-mentioned fissure is hidden by the alisphenoidal lamella. There is no long bony canal for the optic nerve to traverse, as in *Erinaceus*, also no sub-optic foramen, but a conspicuous orbital foramen opens above and in front of the optic one. There is a large and conspicuous alisphenoid canal, its posterior aperture being just in front of the foramen ovale, but there is no external alisphenoid canal. A considerable posterior palatine foramen on each side leads upwards into a short canal, which opens at the side of the skull by an aperture common to it and to the spheno-palatine foramen, but which is widely separated

from the opening representing the foramen rotundum and sphenoidal fissure. There is a small anterior palatine foramen on each side. The infra-orbital foramen is large and single, and is the anterior opening of a very short canal. The lachrymal foramen opens above and a little behind it, but in front of the anterior margin of the orbit.

Two mental foramina open, at some distance from each other, outside the horizontal ramus of the mandible. The more anterior, between the canine and first premolar; the more posterior, beneath the last premolar or the first molar.

The dental formula is: I. $\frac{2-2}{3-3}$, C. $\frac{1-1}{1-1}$, P. M. $\frac{3-3}{3-3}$, M. $\frac{3-3}{3-3}=\frac{18}{20}=8$.

The 1st upper incisor is separated from its fellow of the opposite side by an interval, and also by another from the second incisor. Both incisors are small, of nearly the same size, and the crown of each is peculiarly notched behind, and so consists of a large anterior lobe with an exceedingly small posterior one. The posterior incisor is very much curved. The canine is very large, with a simple crown and root, and is like that of a carnivorous animal. It is separated by wide intervals from both the incisors and premolars and its anterior margin coincides with the premaxillary suture.

The 1st premolar consists of a simple conical cusp with a very small posterior talon. It has two roots. The 2nd premolar is much larger, and indeed is rather the largest as well as certainly the most vertically-extended of the upper grinders. It consists of one very large conical cusp, which has a small external talon and a supplementary postero-internal cusp, so that it possesses one large anterior prominence and two very small posterior ones; one of the latter being external, the other internal. The next tooth (which I am inclined to consider as the 3rd premolar) differs from any tooth we have yet met with, and resembles one of the triangular prisms of a molar of *Tupaia* or *Talpa;* it may be considered as a triangular prism (with one angle turned inwards) set upon a somewhat larger base, or it may be described as bearing 6 cusps, 3 external, one median, and 2 internal. The median is the principal, and appears to answer to one of the median cusps of a grinder of *Tupaia.* The 3 external cusps are very minute, and appear to be developments of the cingulum; the two posterior of these three constitute the outer limit of the grinding surface of the triangular prism. The 2 internal cusps are also minute and are developments of the internal cingulum or base, on which the triangular prism may be said to be imposed.

The 1st and 2nd upper molars are quite similar to the third premolar, except that the external cingulum sometimes gives rise to four minute cusps. The third and last upper molar is essentially similar, but is rather more compressed antero-posteriorly, and the part which in the other molars is the outer surface of the prism, looks more backwards.

In the lower jaw the 1st incisor is very small, and in contact both with its fellow of the opposite side, and with the 2nd incisor. Its crown is simple. The 2nd incisor is larger and its crown is bilobed, the posterior lobe, however, being very small. The 3rd incisor is separated by an interval from the 2nd, and is smaller than the latter. It appears, however, to be sometimes bilobed. The lower canine is a large conical tooth with simple fang and crown, the latter being more or less grooved internally in a vertical direction. As is well known its summit is received into a peculiar fossa of the premaxilla. The canine is separated by a slight interval from the third incisor.

The 1st premolar is a small conical tooth with two roots and a single cusp, which is, however, provided with a small posterior talon.

The 2nd premolar is similar in form to the first, but much larger, being, indeed, the most vertically extended grinder of the lower jaw. The next

tooth (which I am inclined to consider as the 3rd premolar) has a certain resemblance to the first lower true molar of *Erinaceus*, if we imagine the posterior cusps with their connecting ridge to be almost aborted. It may be considered as a triangular prism (with an angle turned outwards) placed on a base which projects behind, but scarcely in front of it. It may, therefore, be described as consisting of 3 lofty cusps, external, antero-internal and postero-internal, connected by ridges and together forming the prism. The external cusp has a rudimentary supplemental cusp at its base in front and one rather more marked behind; the postero-internal has also a supplemental cusp at its base behind, and this is connected by a low transverse ridge with the posterior supplemental cusp of the large external cusp. The next three molars are quite similar to the third premolar except that the fourth and last has not a transverse ridge, but only a low cusp behind its triangular prism.

As regards the rest of the skeleton of *Centetes*, it may be observed that there are 18 or 19 dorsal, 5 lumbar, and 3 sacral vertebræ. The spinous process of the axis is enormously large, and the other cervical vertebræ have all more or less elongated spinous processes. The cervical transverse processes are not much antero-posteriorly expanded. The dorsal spines are elongated, and those of the lumbar vertebræ are very much enlarged and antero-posteriorly extended. The lumbar metapophyses, anapophyses, and transverse processes are small, but the lumbar spines develope tolerably marked hyperapophyses. There are no hypapophysial processes. The manubrium is of moderate size and not keeled. The clavicles are elongated.

The scapula has the supra- and infra-spinatus fossæ of about equal size, but the metacromion process is obtuse and truncated. The free margin of the spine of the scapula is undulating. The humerus is only slightly longer than the scapula, and has a supra-condyloid foramen, but no inter-condyloid perforation. The radius and ulna are complete and distinct, and the carpus is provided with a scapho-lunar bone and also an os intermedium.

The pelvis is very wide, with a very small pubic symphysis. The ilium is not markedly concave either within or without. The femur has but a slight external gluteal ridge, but there is a deep excavation (wanting or very slight in *Erinaceus*) at the lower end of the front of its shaft. The tibia and fibula are both complete, their whole length not anchylosing together inferiorly. The metatarsus is short.

Having thus reviewed the cranial and dental characters of the six typical forms: 1, Erinaceus; 2, Talpa; 3, Sorex; 4, Tupaia; 5, Macroscelides; and 6, Centetes, with some notice of other skeletal structures, it remains to examine the other genera of the order Insectivora, and endeavour to ascertain their affinities and relations.

HYLOMYS. This genus is unfortunately only known to me by the figures in Herm. Schlegel and Sal. Müller's memoir[1] on the genus. It is an inhabitant of Java and Sumatra[2], and shews much resemblance to the Sumatran and Bornean form *Tupaia*, to which it is evidently nearly allied. As far as can be judged from the figure and description of the memoir, the only points in which it appears to differ from the description of the last-mentioned genus, which has been already given, are as follows. The skull tapers less from behind forwards, both vertically and transversely, and its roof is rather more narrowed between the orbits, which last are

[1] *Verhandelingen over de natuurlijke geschiedenis der Nederlandsche overzeesche begittingen door de Leden der Natuurkundige commissie in Indië en andere Schrijvers.* Uitgegeben op last van den Koning door C. J. Temminck. Leiden, 1839—1844, p. 153. *Beschrijving van een merkvaardig insektenetend zoogdier.* Hylomys suillus, door Sal. Müller en Herm Schlegel, Pl. XXVI. fig. 1. External form Pl. XXV. figs. 4—7 skull.

[2] This genus is also represented in the Tenasserim provinces; see Blyth, *Journal Asiat. Soc.* Bengal, 1859, p. 293.

unenclosed by bone behind, there being but a mere trace of a post-orbital process. The palate presents no defects of ossification, but there seems to be a slight median antero-posterior ridge, and the posterior margin of the palate to be very slightly thickened. The pterygoid fossa appears to differ much from that of *Tupaia*, as it is represented[1] as extending forwards as far as the posterior margin of the palate. As the base of the cranium proper is not figured, I am unable to say whether there is an external alisphenoidal canal, or whether the meso-pterygoid fossa narrows from before backwards, &c.

The nasals do not extend backwards, on the upper surface of the skull, nearly so far as do the maxillæ; the malar has a much smaller perforation[2], and the anterior part of the outer surface of the zygoma is more excavated.

The mandible has a rather stouter horizontal ramus than that of *Tupaia*, but the condyle has a very slight transverse extent.

The foramina generally cannot be described from the figures, but the infra-orbital canal is rather larger, but scarcely shorter than in *Tupaia*, and the situation of the lachrymal foramen is similar, the anterior palatine foramina on the other hand are smaller.

The dentition is $\text{I.}\ \frac{3-3}{3-3},\ \text{C.}\ \frac{1-1}{1-1},\ \text{P. M.}\ \frac{4-4}{4-4},\ \text{M.}\ \frac{3-3}{3-3} = \frac{22}{22} = 44.$

The 1st upper incisor, on each side, is of considerable size, conical and curved; the 2nd is much smaller, and separated from the first by an interval; the 3rd is close to the second, and rather smaller than the latter. The canine appears externally a little behind the premaxillary suture, and is about as far separated from the third incisor as the second one is from the first. It appears to have two roots and a marked posterior talon. The 1st upper premolar is a very small, conical tooth; the 2nd is a little larger with one minute prominence in front of, and one behind the main cusp. In the 3rd premolar these are rather more marked, and much more so in the 4th, which is the most vertically extended grinder of the upper jaw, and as, at the same time, there are two well-developed internal cusps, this tooth, when its grinding surface is looked at, has the aspect of a true molar; and there is a greater difference in size between it and the third premolar, than there is between any other two contiguous grinding teeth in the upper jaw.

The first true molar is formed essentially on the same type as the corresponding one of *Tupaia*, but the triangular prisms are very small and the postero-internal cusp is largely developed, so that it approximates to the structure of the first molar of *Erinaceus*, and presents us with a very interesting transitional condition. The 2nd molar resembles the first; the 3rd is much smaller, and appears to be tricuspidate.

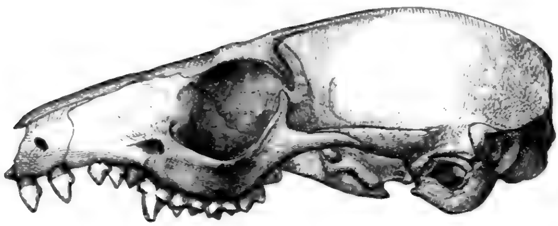
In the lower jaw the incisors are rather long and slender and also procumbent and, as in *Tupaia*, the third on each side is shorter than the first and second. The canine, however, is shorter, less pointed, and closer to the incisors than in the last named genus. The 1st premolar is an exceedingly small and simple tooth, the 2nd is scarcely larger, but the 3rd is decidedly so, with small supplementary cusps, one in front of, the other behind, the principal one. The 4th premolar is the most vertically extended grinder in the lower jaw, and there is a greater difference in size between it and the third than between any other two contiguous inferior grinders. The three true molars appear closely to resemble the corresponding teeth of *Tupaia*.

As regards the rest of the skeleton I have no information, but most probably it has great resemblance to that of the last-named genus.

[1] *Loc. cit.* Pl. XXV. fig. 6.

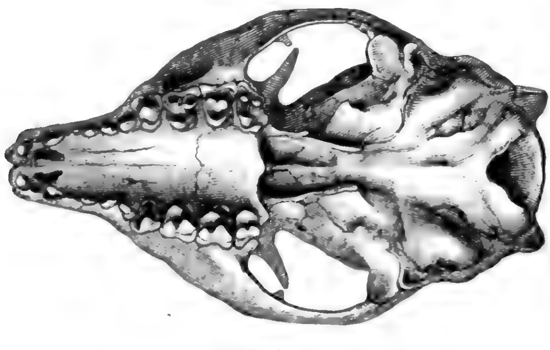
[2] J. A. Wagner Schreber's *Säugthiere Supplementband fünfte Abtheilung*. 1855, p. 530.

PTILOCERCUS. This pleasing form, first described by Dr Gray[1], is evidently more closely related to *Tupaia* than it is to *Hylomys*. Its



PTILOCERCUS. Scale, 2 natural size.

skull and dentition present similar characters to those described as existing in the former of those two genera, except that the muzzle is rather less attenuated, while the cranium proper is more so—the skull being relatively more narrow transversely immediately behind the post-orbital processes. The zygoma is rather stouter relatively, and has a more outward sweep, and the malar foramen, is very much smaller. The anterior margin of the orbit is not sharply prominent, nor is there any distinct process above the lachrymal foramen, though the skull has a slightly swollen appearance at that part. The temporal ridges do not meet, but separately join the lambdoidal ridge, which is less prominent medianly, and more so on each side than in *Tupaia*. The temporal fossa is much larger, and the orbit relatively smaller. The latter is all but completely encircled by bone, but in the specimen in the British Museum the point of the post-frontal process does not quite join the ascending process of the malar: it is long enough to do so, but on each side it passes down a little within the extremity of the malar process. The posterior margin of the palate is slightly thickened, and is concave on each side of a median prominence. There are no defects of ossification in the palate, though the bone is exceedingly delicate. The pterygoid and meto-ptery-

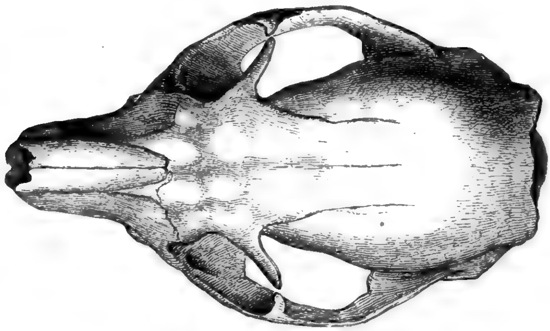


PTILOCERCUS. Scale, 2 natural size.

goid fossæ are as in *Tupaia*, except that the former are somewhat larger on account of the greater extent of the ecto-pterygoid plates. The pterygoid fossæ however do not approach near to the posterior margin of the palate. There is a very small ridge-like paramastoid process and a rather well-developed post-glenoidal one. As has been mentioned, the malar

[1] *Pro. Zool. Soc.* 1848, p. 24, Pl. II., and *Zoology of Voyage of H. M. S. Samarang*, 1850. *Mammalia*, p. 18, Pl. V.

perforation is very small. The angle of the mandible can hardly be said to be at all inflected. On the *basis cranii* a notch on each side of the basi-occipital allows a portion of the periotic bone to be seen just within each auditory bulla. In the skull examined no partition could be detected between the sphenoidal fissure and the foramen rotundum, the two being represented by a single aperture. The external alisphenoidal canal is larger than in *Tupaia* there is no supra-orbital foramen; and the meatus auditorius externus is separated from the glenoid surface by the post-glenoid process and foramen. The infra-orbital foramen is relatively rather larger, and its canal is much shorter. The spheno-palatine and posterior palatine foramina are very small. The others are as in *Tupaia*.



PTILOCERCUS. Scale, 2 natural size.

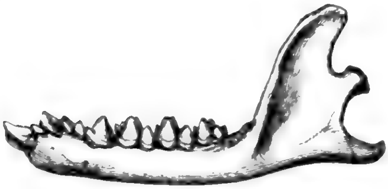
The dental formula I am disposed to consider should be the same as in the last-mentioned genus, i. e.

$$\text{I. } \frac{2-2}{3-3},\quad \text{C. } \frac{1-1}{1-1},\quad \text{P.M. } \frac{3-3}{3-3},\quad \text{M. } \frac{3-3}{3-3} = \frac{18}{20} = 38;$$

but there are differences in the relative size of the different teeth. The teeth however are, as in *Tupaia*, except in the following particulars:

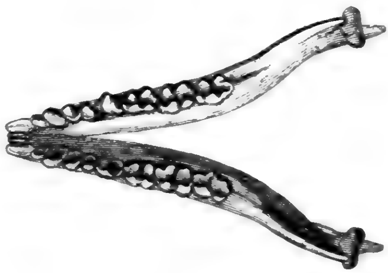
The 2nd incisor appears externally at the premaxillary suture; but, as far as can be ascertained without mutilating the specimen, its root is in the premaxilla; on this account I consider it an incisor, and also because the lower tooth, which passes in front of it, has all the appearance of an inferior incisor. The upper canine is situated about as much behind the second incisor as that is behind the first; it has two roots, and is of similar form and size to the first premolar which is in contact with it. The 2nd premolar is very little bigger than the first, it is however more transversely extended. The 3rd premolar is the most vertically extended tooth in the upper jaw, and is formed like its homologue in *Tupaia*. The true molars are formed on quite the same type as those of the last-mentioned genus, only the external cingulum is a mere band, and does not develope cusps, so that the grinding surface does not present triangular surfaces. The last molar has but one external, one internal, and two median prominences.

In the lower jaw the 2nd incisor on each side is much larger than the first, and still more so than the third one, which is very small. In this respect *Ptilocercus* differs more from *Tupaia* than *Hylomys* does. The canine is almost as large as the second incisor. Each inferior tooth is in contact with two others except the last molars, which of course are each in contact but with one. The 1st and 2nd premolars are very small, simple, conical teeth. The 3rd premolar is more simple in structure than in *Tupaia;* consisting, as it does, of one large cusp with a very small



PTILOCERCUS. Scale, 2 natural size.

anterior one and with a posterior talon. The lower true molars much resemble those of the last-named genus.



PTILOCERCUS. Scale, 2 natural size.

Of the rest of the skeleton I am ignorant, but most probably it closely resembles that of *Tupaia*, to which evidently *Ptilocercus* is far more closely allied than to any other of the six typical forms before noticed.

Leaving these Asiatic genera, and turning to the African one recently discovered by Dr Peters, and described by him under the generic name *Petrodromus*[1] (a skeleton of which form is in the national collection), we there find a great approximation to our fifth type, *Macroscelides*. Indeed it corresponds with the description before given of that genus, except in the following particulars. The temporal ridges unite to form a short but strongly marked sagittal ridge joining the lambdoidal, which is most elevated towards the middle line. The posterior margin of the palate is on a line with the anterior end of the last molar[2]; it has a marked median prominence. The auditory bullæ are not quite so large. The narrow lamella (separating the foramen ovale from the opening representing both the foramen rotundum and spheno-orbital fissure) has a small perforation, which may be from its situation the true vidian foramen[3]. The sub-optic foramen is very conspicuous[4].

The 1st upper incisor is relatively larger than in *Macroscelides*. The 3rd incisor is much larger than the second, though smaller than the first; it has two roots. The 2nd upper premolar has only one cusp with the posterior margin of its crown slightly notched. The 3rd upper premolar has externally very much the same aspect as the 2nd, but its internal part is so developed that it is almost quadricuspidate; the posterior cusps however are all but obsolete, while the antero-external cusp is much more vertically extended than is the antero-internal one. The second and third

[1] *Bericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin*, 1846, p. 257, and *Reise nach Mossambique Zoologie*. I. Säugethiere, p. 92. Dr Peters has given a most excellent and minute account, which I here in part repeat.

[2] Behind in Dr Peter's figure, *loc. cit.* Tab. XXII. fig. 11.

[3] See the late Mr H. N. Turner, Junr.'s paper in the *Pro. Zool. Soc.* 1848, p. 72.

[4] See Dr Peter's figure, Tab. XXII. fig. 8, where it is plainly shewn just in front of the optic foramen, for which it might well be mistaken.

premolars are but very slightly, if at all, more extended vertically than are the two molars, which have the same form as in *Macroscelides*.

In the lower jaw the anterior incisor[1] is not in contact with its fellow of the opposite side, and small intervals separate the third incisor, the canine and first two molars, from their neighbours[2]. The canine is similar in form to the first premolar, being trilobed, but the posterior lobe is very small. The true molars are as in *Macroscelides*, except that the anterior cusp is obsolete in the second as well as in the third molar.

As regards the rest of the skeleton, there are 13 dorsal, 7 lumbar, and 3 sacral vertebræ. The spinous processes of the cervical vertebræ are very small, except that of the axis, which is large. The lumbar transverse processes are short, but extremely developed antero-posteriorly. The olecranal fossa of the humerus is sometimes perforated[3]. The scaphoid and semilunar bones are distinct, and there is an os intermedium[4]. This form differs from all that have been here examined, in that it has but four digits to each pes. Altogether *Petrodromus* is most unquestionably the close ally of *Macroscelides*.

Rhynchocyon. This interesting African form, also discovered and first described by Dr Peters[5], resembles *Macroscelides* to a considerable extent, but not nearly as much as does *Petrodromus*. It agrees with the former genus (our 5th type) in all the characters before described except as follows: the skull is much broader, relatively as well as absolutely, and also flatter, and it is very much less narrowed between the orbits, which are furnished with a marked post-orbital process, and indeed are surrounded by bone for about five-sixths of the circumference of each. The anterior nares are quite vertical, and, judging from Dr Peter's figure (for the specimen in the British Museum is imperfect) the plane of the foramen magnum looks mainly backwards. The anterior margin of the orbit is not quite so sharply prominent, and there does not appear to be a distinct *os orbitale anterius*. Cranial ridges are (as in *Petrodromus*) more marked, as also the concavity on the muzzle in front of each orbit. The antero-posteriorly directed groove on the dorsum of the muzzle is less deep relatively, and extends less forwards, while the anterior end of that part curves slightly upwards. The palate is decidedly, though slightly, concave antero-posteriorly, and without any defects of ossification. Its posterior margin, which extends back some little distance behind the last molars, has a strong median projection, and three others on each side; between these are six intervals, each with a more or less concave margin. The pterygoid fossæ (judging from Dr Peter's figure) do not extend forwards nearly to the posterior margin of the palate, the ecto-pterygoid plate being a narrow process projecting downwards, outwards and backwards. In which respect *Rhynchocyon* resembles *Tupaia*. The auditory bullæ are not so large relatively. There does not appear to be any paroccipital process, but a moderately developed mastoidal one. The premaxilla is much smaller relatively, and is not prolonged up beside the nasals. Its posterior margin is also less curved. The excavation on the surface of the malar and maxilla is deeper and more extensive. The ascending ramus of the mandible is less high, and its anterior margin forms a more open angle with the alveolar one. The angular process is short, rather obtuse, and does not project at all

[1] Dr Peters found each lower incisor to have a bilobed crown, *loc. cit.* p. 95, and Tab. XXII. fig. 9.

[2] i. e. in the British Museum specimen. It does not appear to have been the case in the individual figured by Dr Peters.

[3] Peters, *loc. cit.* p. 96.

[4] Peters, *loc. cit.* p. 96, and Tab. XXIII. figs. 6 and 6a, n, s, x.

[5] *Monatsbericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin.* 1847, p. 36, and *Reise nach Mossambique Zoologie.* Saügethiere, p. 100. Tabs. XXI. XXII. figs. 1—7, and XXIII. figs. 1—5.

downwards. A small vidian (?) foramen opens beneath and in front of the aperture, which represents both the foramen rotundum and the sphenoidal fissure. The sub-optic foramen is as conspicuous as in *Petrodromus*[1]. The infra-orbital canal is very long. The *meatus auditorius externus* has a smaller opening, which looks less backwards than in *Macroscelides*. The spheno-palatine foramen is very small, and opens just outside the meso-pterygoid fossa and above the posterior margin of the palate. There is no supra-orbital foramen, but in Dr Peter's[2] specimen the orbital margin is deeply notched. The lachrymal foramen, though well within the orbit, opens in front of the posterior termination of the infra-orbital canal, which is prolonged backwards to above the last molar, instead of terminating nearly above the interspace between the penultimate and the antepenultimate molars. The posterior palatine canal is smal', and opens inferiorly at about the anterior end of the posterior fifth of the palate. The mental foramina open near the inferior antepenultimate true molar and a larger one beneath the first premolar.

The dental formula is

$$\text{I. } \frac{1-1}{3-3} \text{ or } \frac{0-0}{3-3}, \quad \text{C. } \frac{1-1}{1-1}, \quad \text{P. M. } \frac{3-3}{3-3}, \quad \text{M. } \frac{3-3}{3-3} = \frac{16 \text{ or } 14}{20} = 34 \text{ or } 36.$$

In the upper jaw the single incisor on each side is very minute or absent. The canine is large and double-fanged. It has a simple conical crown, nearly flat externally, but strongly convex internally. It is situated very near to the premaxillary suture. The 1st premolar is a small laterally compressed double-fanged tooth, with traces of an anterior and a posterior minute cusp on each side of its base. The 2nd premolar is rather larger, it has a similar trace of an anterior cusp, but posteriorly it is doubly-notched, producing thus two small cusps on its posterior margin. The 3rd premolar is less vertically extended than the 2nd; it has the anterior cusp decidedly more developed and the two posterior slightly more so. The tooth is also pro-

Left dental series of upper jaw of *Rhynchocyon*.

duced internally, the internal production giving rise to a marked anterior cusp and a very small posterior one. These upper premolars are not more extended vertically than are the molars. The true molars are quite like those of *Macroscelides*.

In the lower jaw the three lower incisors are sub-equal, have bilobed crowns (the lobes being also sub-equal), and are in contact each with the tooth next behind; but the 1st incisor is separated by an interval from its fellow of the opposite side. The canine is very slightly larger and has a simple crown. The 1st premolar is a simple, conical, double-fanged tooth. The 2nd premolar is similar to the first, except that it is not quite so vertically extended and that its posterior margin bears two slight notches. The 3rd premolar is rather more extended, both antero-posteriorly and transversely, the posterior notches are deeper, while there is a trace of a small anterior lobe. The true molars are quite similar to those of *Macroscelides*, except that the 3rd is smaller as compared with the 1st and 2nd than is the case in that genus.

As regards the rest of the skeleton, according to Dr Peters[3], there are 13 dorsal, 8 lumbar and 3 sacral vertebræ. "The development and direction of the processes show a great agreement with *Macroscelides*," but the

[1] See Dr Peter's figure. *Reise nach Mossambique*, Tab. XXII. fig. 1.
[2] *Loc. cit.* Tab. XXII. fig. 3. [3] *Loc. cit.* p. 103.

cervical spinous processes are large, especially that of the axis. The antero-posterior extent of the lumbar transverse process is remarkable[1]. The form of the anterior margin of the scapula resembles that of *Macroscelides*, also the development of the metacromion. The two perforations at the distal end of the humerus are also present, but the ulna is complete, and not anchylosed to the radius. The carpus is provided with separate scaphoid and semilunar bones, also an *os intermedium*, but there is no pollex, and the fifth metacarpal extends upwards and joins the *os pisiforme*. The pes is not provided with a hallux, at least there is only a rudiment of its metatarsal bone. The tibia and fibula anchylose together above the middle of the leg, and the metatarsus is much longer than the tarsus and about as long as the longest digit.

GYMNURA[2]. This Asiatic form possesses a cranium which, at the first glance, appears somewhat intermediate between *Erinaceus* and *Centetes*. Its size (especially its length), its large lambdoidal ridge and long canine teeth, recall the last-named genus, but, as has been generally recognised, its true affinities are with *Erinaceus*. Indeed the description given of our first type will altogether apply to *Gymnura*, except as regards the following particulars.

The skull is larger and more elongated and the constriction between the orbits is more marked. The zygomata are more slender, and the skull is less truncated anteriorly, the anterior nares sloping more backwards. The concavity on the dorsum of the skull, between the orbits, is less marked, and sometimes not discernible. The palate is widest between the last molars, it has no defects of ossification, and is continued backwards for some distance behind the last molar. The transverse plate behind the posterior palatine ridge is bounded externally by a ridge continued forwards from the free inferior margin of each pterygoid, and therefore is not continuous with the outer walls of the pterygoid fossæ, which are not so large as the inner ones, but are perforated by an external alisphenoidal canal. The mesopterygoid fossa ends in no excavation, but its roof is continuous with the rest of the under surface of the basis *cranii*. The paroccipital process and the two projections of the mastoid are relatively smaller. The premaxilla, though it runs back beside the nasal, appears here to meet the anterior prolongation of the frontal. The nasals are not quite so narrow relatively as in *Erinaceus*, nor do they extend backwards nearly so far as do the maxillæ. The mandible has the inside of its ascending ramus, above the mylohyoid ridge, not so convex, and the coronoid process is broad and truncated. The venous foramen at or near the junction of the parietal and squamosal is situated above, but behind, the post-glenoid process. The optic foramen is very small and opens anteriorly, at the end of a long bony canal, much in front of the sphenoidal fissure. Above its anterior opening are the orbital foramen and the anterior aperture of the venous channel, which, as in *Erinaceus*, traverses the inner surface of the side wall of the cranium. The sub-optic foramen is more conspicuous than in *Erinaceus*, and being situated just in front of the sphenoidal fissure, might, when the outside of the skull alone is looked at, be readily taken for the optic foramen. Another foramen is situated on the inner wall of each optic foramen, and appears to lead from the cranial cavity into the one into which the sub-optic foramen opens.

The spheno-palatine foramen is situated just above the posterior palatine one, and is remote from the foramen rotundum. The lachrymal foramen appears to be, though it is not really so, more within the orbit than in

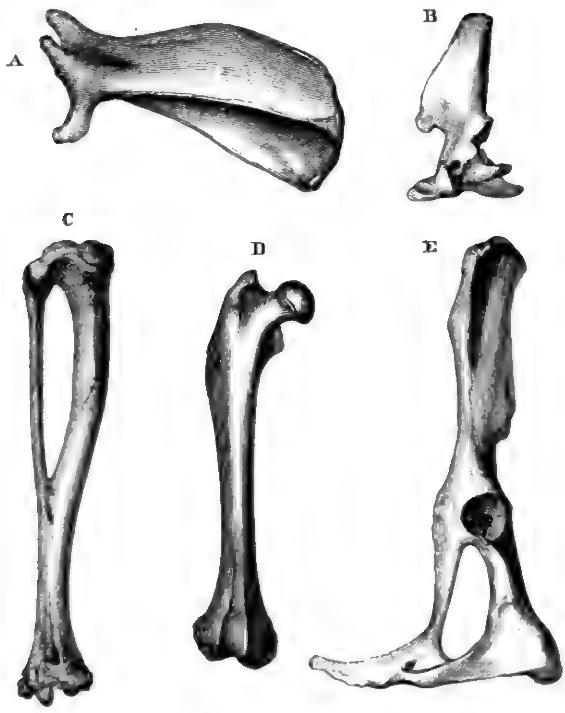
[1] See *loc. cit.* Tab. XXIII. fig. 1.

[2] The skull is figured by De Blainville, *loc. cit.* Pl. VI. For the dentition see the same, Pl. X. Owen has represented both the skull and teeth. See *loc. cit.* Pl. CXI. figs. 4, 4a and 4b.

Erinaceus. This is because the ridge and process in front of it is so strongly marked. The large mental foramen opens beneath the last premolar.

The dentition is $\text{I.}\ \frac{3-3}{3-3},\ \text{C.}\ \frac{1-1}{1-1},\ \text{P. M.}\ \frac{4-4}{4-4},\ \text{M.}\ \frac{3-3}{3-3} = \frac{22}{22} = 44.$

In the upper jaw the 1st incisor is a large, conical, somewhat curved and rather acutely-pointed tooth, separated by a considerable interval from its fellow of the opposite side, for its whole length, as the two do not converge as they descend. The 2nd incisor is similarly shaped but much smaller, and the third is smaller still, and is much in front of the premaxillary suture. The canine is a large, conical, simple-crowned, double-fanged tooth; it is about as long as the first incisor but rather more antero-posteriorly extended. There is a considerable interval between the canine and the 3rd incisor. It is close to the premaxillary suture. The 1st premolar is a very small, simple, conical tooth, though with a marked cingulum. The 2nd premolar is like the first, only somewhat longer. The 3rd premolar is much larger, and the difference between it and the second is greater than that between any other two contiguous superior grinders; its external cingulum developes one rudimentary cusp in front of the crown and another behind it, while the internal one gives rise to a considerable cusp. The 4th premolar is quite like the third premolar of *Erinaceus*, except as regards its preponderance over the tooth next in front. It is the most vertically-extended of all the upper grinders. The first and second molars are like those of *Erinaceus*, the third molar has a triangular grinding surface, one angle of the triangle being posterior. It



Bones of *Gymnura*. Natural size. A. Scapula. B. Axis vertebra. C. Tibia and fibula. D. Femur. E. Left os innominatum.

is quadricuspidate, three small cusps being situated along its postero-external margin, and another, the largest, at its antero-internal angle.

In the lower jaw the 1st incisor is slightly larger than the 2nd and considerably larger than the third. The canine is large, conical, and pointed, like that of *Centetes.* The 1st and 2nd premolars are exceedingly small, simple, conical teeth. The 3rd premolar is much larger, has a small talon or rudimentary posterior cusp and two fangs. The 4th (and last) premolar is more simple than is the last premolar of *Erinaceus.* It consists of one large cusp, with a posterior talon and three quite rudimentary ones. Of these one is postero-external, one antero-internal, and the third postero-internal. The 1st and 2nd molars are quite like those of *Erinaceus.* The 3rd true molar is quite like the second, and therefore much larger than in the last-named genus.

As regards the rest of the skeleton, judging from an imperfect one preserved in the British Museum, and which once belonged to the collection of the Zoological Society, it appears that there are as many as 15 dorsal, 5 lumbar, and 5 sacral vertebræ [1], and that the caudal vertebræ are numerous. The spinous process of the axis is very large, almost if not quite as much so as in *Centetes* (Fig. B). The vertebral processes are nearly as in *Erinaceus,* also the scapula (Fig. A) and arm-bones, except that there is a supra-condyloid as well as an inter-condyloid perforation. Of the carpus I know nothing. The ilium has a marked external concavity, and the spine of the ischium is singularly prolonged backwards. The obturator-foramen is elongated, the pubic symphysis is minute (Fig. E). The femur has a much stronger gluteal ridge than in *Erinaceus* (Fig. D), and the tibia and fibula (Fig. C) are not anchylosed together quite so high up, and the fossa on their conjoined anterior surface is still deeper.

CONDYLURA. Unfortunately I have not been able to examine any skeleton or skull of this genus, neither is its osteology sufficiently described by De Blainville, though he has given excellent representations of its skull and skeleton [2].

Judging from these the cranial sutures appear to remain longer distinct than in *Talpa,* the *meatus aud. ext.* to be larger and placed more directly beneath the glenoid surface; the anterior end of the skull becomes narrower vertically, as also does the mandible; the pterygoid region seems less inflated, and perhaps there may even be a small true pterygoid fossa. No fissure borders the epiotic.

There are apparently 13 or 14 dorsal and 7 lumbar vertebræ, but the other skeletal characters seem to resemble those of *Talpa,* except that the ribs are more slender, the caudal vertebræ more numerous, and the scapula narrower as well as the humerus; the acromion is large and more slender [3], the manubrium less extended, and the foramen narrower; the sickle-shaped bone is much smaller, and the ultimate phalanges of the manus do not appear to bifurcate. The tibia is relatively longer.

The dentition [4] is $\text{I.}\ \frac{3-3}{3-3},\ \text{C.}\ \frac{1-1}{1-1},\ \text{P.M.}\ \frac{4-4}{4-4},\ \text{M.}\ \frac{3-3}{3-3} = \frac{22}{22} = 44.$

Of the upper incisors the 1st and 3rd are very large, the latter being caniniform. The 2nd is minute. The canine is a little larger than the second incisor, it is caniniform, with a trace of a posterior talon, and separated from the third incisor by a considerable interval. The first three upper premolars are small, double-fanged, laterally compressed teeth, each

[1] The vertebræ and ribs being nearly all separate the number may be greater than is here stated.

[2] *Loc. cit.* Pls. I. and V. and p. 19.

[3] De Blainville, *loc. cit.* p. 20.

[4] See De Blainville, *loc. cit.* Pl. IX. and *Dents des Mammifères,* Pl. XXII. *bis,* where F. Cuvier represents but two incisors above and two below on each side.

with its rudimentary anterior and posterior cusp more developed than in *Talpa;* they are separated by intervals from each other and the canine. The fourth premolar is larger and produced internally. The three true molars appear to resemble almost completely those of *Talpa*, except that in the first the two median cusps are subequal in vertical extent. The two first inferior incisors are of moderate size and smaller than the first upper one. The 3rd lower incisor is very small. The lower canine is large, caniniform, and with a posterior talon. The lower premolars gradually increase in size from before backwards. Each consists of a principal cusp, with a small anterior one, and one or two small posterior ones. When there is only one posterior cusp (as in the first premolar) it is much larger than the anterior one. The true molars are quite like those of *Talpa*, except that the vertical extent of the two external cusps of each is more equal.

SCALOPS[1]. A complete skeleton of *S. aquaticus*, and a detached skull of the same species, are preserved in the Osteological Collection of the British Museum. Both shew a very close resemblance to *Talpa*, and the only differences I have noticed are the following: the lateral constriction behind the orbits is greater, the palate extends backwards a little beyond the last molars, and the glenoid surface is situated a little more behind the foramen ovale, and more directly above, and rather nearer to, the outer opening of the *meatus auditorius externus*. The opening, also, which in *Talpa* borders the epiotic on three sides, appears to be absent, and the spiculum, which encloses superiorly the infra-orbital foramen, is not quite so slender.

The dentition is $\text{I.}\ \frac{3-3}{2-2},\ \text{C.}\ \frac{1-1}{0-0},\ \text{P. M.}\ \frac{3-3}{3-3},\ \text{M.}\ \frac{3-3}{3-3} = \frac{20}{16} = 36.$

In the upper jaw the 1st incisor is very large; the 2nd and 3rd are minute. The canine is large and conical, and much more vertically extended than is the first upper premolar. The 2nd premolar is about as vertically extended as is the canine, and more antero-posteriorly so. The 3rd premolar is more developed. The true molars are quite like those of *Talpa*, except that the cusps of the external cingulum are more equal to the median cusps in vertical extent, and that the internal portion of each tooth is a little less developed.

In the lower jaw the 2nd incisor is much larger than the 1st, and is nearly as long as the 1st upper incisor. The canine is generally considered and represented as absent, but in one of the specimens in the British Museum there is a most minute and rudimentary tooth, which may represent it. In that case the number of the teeth in this genus would be 38[2].

The 1st premolar, the crown of which is received between the upper canine and the first upper premolar, is a small simple conical tooth. The two following premolars are larger (especially the more posterior one), but each is a nearly simple tooth. The true molars are very much like those of *Talpa*.

There are 14 dorsal, 5 lumbar, and 5 sacral vertebræ. The other osteological characters seem to resemble those of *Talpa*, except that the dorsal metapophyses are less developed and the anterior phalanges of the manus less marked by bifurcating.

SCAPANUS. Of other species, usually comprised in the genus *Scalops*, but with a greater number of teeth than *S. aquaticus* has, one only is repre-

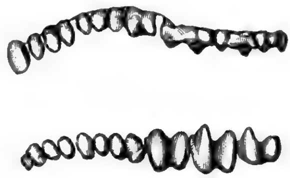
[1] The skull of *S. aquaticus* (the type of the genus) is represented by De Blainville, *loc. cit.* Pl. V. (under the specific name *Virginiana*), and its dentition at Pl. IX. The latter is also shewn by F. Cuvier, *loc. cit.* No. XXII. and by Owen, *loc. cit.* Pl. CX. fig. 2.

[2] Dr Le Conte attributes 38 teeth to this species. *Pro. of Acad. of Nat. Sciences of Philadelphia*, Vol. VI. p. 326.

sented in the national collection, namely *S. Townsendii*[1]. It agrees with the skull of *S. aquaticus*, except that the post-orbital constriction is less marked, and that the palate does not extend backwards beyond the last molars.

The dentition is $\text{I.}\ \frac{3-3}{3-3},\ \text{C.}\ \frac{1-1}{1-1},\ \text{P.M.}\ \frac{4-4}{4-4},\ \text{M.}\ \frac{3-3}{3-3} = \frac{22}{22} = 44.$

The first upper incisor is much larger than the second, the difference being very much greater than in *Talpa.* The two next incisors, the upper canine and the first two premolars, are all small single teeth, of nearly the same size. The 3rd premolar is similar, but slightly larger. The 4th and



Dentition of *Scapanus Townsendii.* Scale, 2 natural size.

last premolar appears to be the first upper tooth, with two fangs. It is essentially like the corresponding tooth of *Talpa*, but the internal and posterior supplementary prominences are more developed. The true molars are like those of *S. aquaticus.*

In the lower jaw the incisors, canines and premolars, are all small, simple teeth, and they increase gradually in size from before backwards. The true molars are like those of *Talpa.* Of the rest of the skeleton I have no knowledge. M. Pomel[2], in 1849, in a very interesting memoir on the geographical distribution of the *Insectivora*, proposed the name *Scapanus* for those species before associated with *S. aquaticus*, but which have 44 teeth. Mr Baird has adopted this as a subgenus, but I am disposed to accord it generic rank[3].

[1] The skull and dentition of this species are represented by Spencer F. Baird, *Mammals of N. America between the Mississippi River and the Pacific.* 1857. Pl. XXX. figs. 1 and 3.

[2] *Bulletin de la Soc. Géologique de France*, Vol. VI. 1849, p. 56.

[3] Dr Le Conte, in a revision of the species of *Scalops*, read before the Academy of Natural Sciences of Philadelphia (see *Proceedings* of that Society, Vol. VI. p. 326), proposed to unite the species with 44 teeth with *Talpa.*

ON THE BRAIN OF DASYPUS SEXCINCTUS. By Prof. Turner, M.B., F.R.S.E.

In most systematic treatises on Comparative Anatomy incidental notices of the brains of the Edentata occur, and in several memoirs especially devoted to the anatomy of various members of this family more detailed descriptions are given. Tiedemann[1] (Pl. v. Fig. 8) figures and describes the brain of Myrmecophaga didactylus. Rapp[2] figures and describes the brain of Bradypus cuculliger. Hyrtl[3] describes the brain of Chlamydophorus truncatus, and compares it with that of Dasypus gymnurus. Tiedemann (Pl. v. Fig. 10), Rapp and Alessandrino[4] describe and figure the brain of Dasypus novemcinctus, and Tiedemann (Pl. iv. Figs. 9 & 10) and Flower[5] have given figures and descriptions of the brain of Bradypus (Cholœpus) didactylus. I have seen no special reference to the brain of Dasypus sexcinctus; and as I recently acquired a perfectly fresh adult female specimen of this animal I purpose giving an account of its cerebral characters.

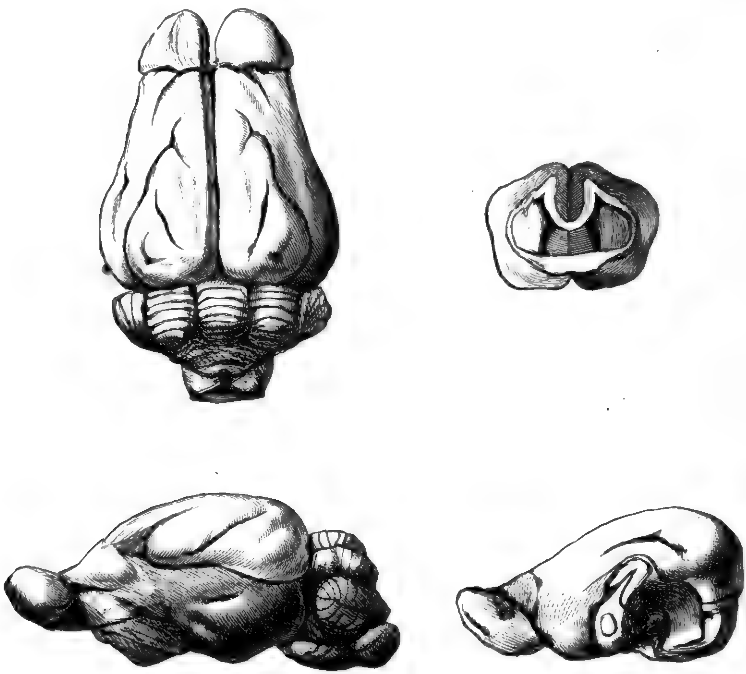
Dimensions.	Inches.
Extreme length of encephalon	2·0
Length of olfactory lobe	0·5
Length of inner face of cerebral hemisphere	1·1
Length of cerebellum	0·6
Greatest breadth of cerebrum	1·5
Greatest breadth of cerebellum	1·0

When a bird's-eye view of the encephalon was taken the olfactory lobes, separated from the cerebrum by a transverse constriction, were seen to lie well in front of its anterior end, whilst the occipital surface of the cerebellum was behind its posterior extremity. From the close relation between the tentorial surface of the cerebellum and the corresponding aspect of the cerebrum, the pineal gland and corpora quadrigemina were entirely concealed. The cerebrum itself, symmetrically divided into two hemispheres by the longitudinal fissure, was elongated in form and flattened superiorly, much broader towards its posterior end than anteriorly. The outer face of each hemisphere presented a shallow depression which indicated the position of the Sylvian fissure, more distinctly marked, however, on the under surface through the elevation in front and behind it of the orbital lobe and natiform protuberance. Above the Sylvian fissure a long and shallow sulcus ran in the antero-posterior direction. It commenced anteriorly by the junction of two short fissures, whilst posteriorly it turned round the hinder end of the cerebrum to the inner surface, where it became continuous with the fissure of the hippocampus. Between this and the longitudinal fissure a short and simple fissure extended for 4-10ths of an inch in the antero-posterior direction, whilst a deep fissure, commencing at the constriction of the olfactory lobe, extended for nearly half an inch obliquely backwards. By these fissures the outer face of the hemisphere was imperfectly divided into three tiers.

When the hemispheres were separated the corpus callosum was seen to be only 3-10ths of an inch long, so that the corpora quadrigemina projected behind it. On the inner face of the hemisphere a calloso-marginal sulcus, 4-10ths of an inch long, was seen. In front it did not pass as far as the

[1] *Icones Cerebri Simiarum et Mammalium rariorum.*
[2] *Anatomische Untersuchungen über die Edentaten.* 1843.
[3] *Denk. der Kais. Akad. Wien.* ix. 1855.
[4] *Mem. della Acad. di Bologna.* vii. 1856.
[5] *Philosophical Transactions*, 1865, p. 639.

anterior end of the corpus callosum, but posteriorly it extended behind it. The corpus callosum was inclined obliquely upwards and backwards, it came to a free-pointed end in front, without genu or rostrum, whilst posteriorly it was rounded and continuous with the thickened band of fibres, called 'psalterium,' which connected together the great hippocampi. The interventricular septum was situated beneath the corpus callosum and in front of the psalterium. The corpus fimbriatum fornicis formed the free edge of the hippocampus major. The fornix was prolonged for the most part behind the anterior commissure, but some of its fibres were continued along the interventricular septum and descended in front of the anterior commissure. The anterior commissure was three times larger than in the brain of the rabbit. The ventricular aperture was crescentic. The hippocampal sulcus was well-marked and extended upwards as far as the posterior end of the corpus callosum, where it disappeared in the callosal gyrus. The fascia dentata possessed considerable breadth below and was prolonged upwards as a fine process behind the corpus callosum and then forwards as a narrow strip, parallel to its upper surface, as far as its anterior end between it and the callosal gyrus.



View of the upper, outer, and inner surfaces, and of a vertical transverse section through the brain of Dasypus sexcinctus.

When a vertical transverse section was made through the hemisphere in the plane of the anterior commissure the corpus callosum was seen to turn sharply upwards towards the superior surface of the hemisphere, from which circumstance the ventricular cavity also ascended. The interventricular septum was 1-5th inch broad. It rested below on the anterior commissure, whilst, above, it came in contact with the corpus callosum. The anterior commissure, nearly twice as thick as the corpus callosum,

passed outwards into the corpora striata, which were large in proportion to the size of this part of the hemisphere.

The olfactory lobes were hollow and connected to the cerebrum by a strong peduncle, which passed backwards to the outer side of the elevated orbital lobule. The optic tracts and commissure were not strongly marked. The corpora albicantia were not visible. The pons 6-10ths inch broad. Optic thalamus possessed a corpus geniculatum. The depressions subdividing the corpora quadrigemina were distinct, the testes overlapped the nates externally and came into relation with the optic thalami. Pineal gland small and placed on anterior part of nates, its peduncles well-marked. Posterior commissure much smaller than the anterior.

The middle lobe of the cerebellum was well-developed. The lateral lobes and the middle cerebellar peduncles were feeble. The medulla oblongata possessed considerable thickness.

Amongst the Edentata the surface of the cerebrum, as regards the presence or absence of convolutions, exhibits a by no means uniform appearance. Though by some anatomists classed along with the Insectivora and Rodentia as mammals with smooth brains, an arrangement which is supported by Tiedemann's description and drawings of the brains of Dasypus novemcinctus and Myrmecophaga didactylus, and which Rapp's description of D. novemcinctus in a great measure confirms, the Edentata are not throughout characterised by this simplicity of cerebral structure. For Alessandrino states that in the specimen of D. novemcinctus he examined faint sulci on the outer surface of the hemisphere furnished indications of convolutions, Tiedemann and Rapp describe the presence of gyri on the brain of Bradypus and Cholœpus, and in the specimen of D. sexcinctus now described the subdivision of the outer surface of the hemisphere by shallow sulci was undoubted. On the inner surface also a short calloso-marginal sulcus was visible and the hippocampal sulcus was well-marked, their general arrangement closely corresponding with the description and figure given by Mr Flower of the same parts in Cholœpus didactylus. In the size and position of the corpus callosum and in the general arrangement of parts about the ventricular aperture the brain of this species of Dasypus closely agreed with Cholœpus; the fascia dentata, however, seemed in the former to be prolonged further forward on the upper surface of the corpus callosum than in the latter.

The examination of the brain of Dasypus enables me to point out in the Edentata, what I have already done in the Rodentia, Insectivora, Cheiroptera and Marsupialia[1], that the tentorial surface of the cerebellum is in close relation with the hinder end of the cerebrum, and that so long as these parts are *in situ* the corpora quadrigemina and pineal gland are concealed. Hence, not only Tiedemann, but Cruveilhier and Stannius, have committed an error in describing these bodies as uncovered by the cerebrum: a mistake which, probably, originated from not taking sufficiently into consideration the displacement of parts which to some extent occurs when the brain is removed from the cranial cavity.

[1] *Proceedings of Royal Society of Edinburgh*, March 3, 1862.

NOTES ON AN INSTANCE OF IRREGULARITY IN THE MUSCLES AROUND THE SHOULDER JOINT.

By ALEXANDER MACALISTER, L.R.C.S., *Demonstrator of Anatomy, Royal College of Surgeons, Ireland, Assistant Surgeon to the Adelaide Hospital.*

AN illustration of the gregarious occurrence of variations in the muscles of the forelimb of the human subject has come under my notice within the last session, from which some interesting conclusions may be drawn regarding the correct homologies and homotypical relations of the muscles in the neighbourhood of the shoulder.

While dissecting the right arm of a spare female subject in the anatomy room of the College of Surgeons, I found the following peculiarities. The *subscapularis*, large and fleshy, was divided into two portions by a deep fissure or cleft, lined by an involution of the subscapular aponeurosis; the upper part was triangular and thinner, while the lower was stronger and thicker and quadrilateral in outline. Neither portion perforated the capsular ligament of the shoulder, but a bursa separated the tendon of the upper triangular part from a thin expansion of that structure. These portions had no relation to the twofold arrangement of the fibres described by Sömmering and Cruveilhier; three fasciculi of the superficial and two series of the deep fibres composed the upper part of the mass, while the lower part was made up of the two lower parts of the superficial fibres, and the remainder of the deep portion of the muscle. The interval between these parts of the muscle corresponded to a line drawn from the centre of the lesser tuberosity of the humerus, to the junction of the inferior with the middle third of the vertebral border of the scapula. A triangular fleshy portion slightly separable from the lower edge of the muscle arose from the middle third of the axillary costa, and was inserted into the inferior part of the capsular ligament, and into the inferior border of the neck of the humerus. This portion, although only distinct for the latter third of its extent, seemed to correspond to the small muscular slip which I have found perfectly distinct in some human subjects (subscapulo-capsular or subscapulo-humeral), and which exists distinct from the subscapular in many animals. Segmentation of the subscapularis is an anomaly of infrequent occurrence, and one of which I have but seen one instance before, and in that case the two lower fasciculi of superficial fibres were separated from the rest of the muscle by the circumflex nerve (*Proc. Royal Irish Academy*, 1866, IX. Pl. 7, figs. 1 and 2). The iliacus internus muscle, which is the homotype of the subscapularis, rarely exhibits any similar segmentation, except that the occurrence of the ilio-capsular slip is frequent along the anterior and outer border of the muscle. No trace of a *teres major* muscle could be found, although a careful search was made for it, neither was the *latissimus dorsi* connected to the inferior angle of the scapula; the origin of that muscle was quite normal, and it was inserted into the inner lip, or more accurately into the floor, of the bicipital groove. No bursa existed behind its tendon, such as we generally find separating it from the insertion of the teres major. The latissimus tendon was inserted by two layers, one, the upper, being attached directly to the bone, while the lower half was attached to a tendinous sling united to the humerus above and below, and free in the centre.

The *coraco-brachiales* had likewise a tendinous sling of insertion to which its deep fibres were attached, and this arched over the tendon of the latissimus. This mode of insertion is very common in this muscle, and is figured by Henle, in his *Muskellehre*, as the normal arrangement.

In examining the attachments of the coracoid muscles and ligaments, I found a double ligament of the notch, the deeper slip crossing the supra-

scapular nerve and vein, while the artery crossed beneath the most superficial band. This arrangement is not very uncommon, and is mentioned by Weitbrecht, in his *Syndesmologia*. The coraco-acromial ligament consisted of a quadrilateral narrow band, posterior to which the coracoid process presented a small grooved surface covered by a synovial bursa, over which wound a distinct flattish fasciculus of the pectoralis minor tendon, this portion crossing the root of the coracoid process, wound downwards and outwards, and was inserted into the capsule of the shoulder and into the upper edge of the glenoid cavity. The rest of the lesser pectoral tendon was inserted into the coracoid process; but this continued slip, which was about one-fourth of the entire tendon, passed about one inch beyond the bony process. Such an arrangement of the lesser pectoral is of comparatively rare occurrence, although it is very liable to be overlooked[1].

When, as is generally the case, the coraco-acromial ligament is triangular in shape, it is most frequently deficient for a small extent in the centre, and often a regular semicircular orifice exists opposite about the middle of its coracoid attachment; or, as is not seldom the case, when this ligament is made of an anterior and posterior fasciculus an interval commonly exists between them; to this space a portion of the tendon of the lesser pectoral always corresponds. On the posterior aspect of the coracoid process in ordinary cases there will be found a fibrous band of a variable degree of strength, to which I have given the name coraco-glenoid, from its most ordinary attachments (*Proc. Royal Irish Academy*, IX. Pl. 4, fig. 1, c). This fasciculus, in a specimen before me at present, measures three lines in width and passes obliquely downwards, backwards, and a little inwards, to be inserted into the neck of the scapula and upper margin of the capsular ligament. Tracing the direction of the fibres of this bundle over the upper surface of the coracoid process, we arrive directly at the point of insertion of the pectoralis minor, and this, together with the occasional origin of the ligament from the margin of the deficiency in the coraco-acromial ligament, and with the fact that, in the present instance, no trace of this coraco-glenoid fasciculus could be traced, leads us to the conclusion that it is at least probable that this fasciculus is the displaced and disconnected remains of the prolonged tendon of the lesser pectoral. For, if we take as the starting point of our investigation of the typical arrangement of this muscle—its condition in the bird—we there find the second pectoral winding through an interspace between the outer extremities of the bones forming the scapular arch, in order to be inserted into a point high upon the humerus; then in man we find it attached to the diminished representative of the coracoid bone, with its prolongation to the humerus suppressed, and the muscle converted from an elevator of the humerus to a depressor of the

[1] Mr Wood, who describes a similar anomaly, found it in five cases out of thirty-five; this is, however, probably rather an unusual degree of frequency, as I have not found it to exist much oftener than once in that number of subjects, and in these it is not constant as regards position, course, or being present on both sides. Harrison, in speaking of the lesser pectoral, mentions that "a band of the tendon frequently passes over this process through the triangular ligament, and is connected to it, or to the tendon of the supra-spinatus, or to the capsular ligament of the shoulder-joint" (*Dublin Dissector*, I. p. 79); and Benson mentions that in some rare cases the entire tendon passes through the ligament to join the capsule of the shoulder (*Cycl. Anat. and Phys.* I. p. 359), otherwise this occurrence is passed by in most of the text-books of anatomy. In my own experience I have never seen the entire tendon crossing the coracoid process, but I have found a very large portion of it, about one-half of the whole tendon, so disposed and inserted into the tendon of the supra-spinatus; more commonly a fascicle is connected with the triangular ligament, and most frequently of all the lowest part of the tendon, missing as it were the coracoid process, is inserted into the coraco-brachialis muscle, one step towards the humeral degradation of insertion which we find in many of the Quadrumana and Carnivora.

In the instance under consideration the reflected portion of the tendon was perfectly distinct from the supra-spinatus tendon, anterior to which it was inserted.

scapula. From these considerations it seems probable that, in the irregularity before us, we have as it were a reversion to the original or typical condition of the muscle, and likewise that in many other subjects the sundered representatives of the humeral insertion is to be found in the coracoid attachment and in the coraco-glenoid ligament, otherwise it would be difficult to account for the presence of that band either on morphological or teleological grounds. It seems to be as truly the tendon of the pectoral as the ligamentum teres of the hip is the altered homotype of the intra-capsular portion of the long head of the biceps brachii in the shoulder.

Cases are on record of other pectoral attachments to the capsule of the shoulder, the most interesting being that described by A. De Souza, in which the pectoralis minor was directly attached to the capsular ligament, no mention being made of any trochlear relation to the coracoid process (*Gazette Medicale de Paris*, 1855, No. 12). This seems to be similar to the mode of insertion found in many of the Quadrumana, a lowering of the insertion explicable, in the manner before alluded to, from the diminution of the coracoid bone. Gantzer records the presence of a muscular slip passing from the cartilage of the first rib to the capsule of the shoulder beneath the pectoralis minor, but this would represent more probably the third pectoral of the bird.

This irregularity may perhaps indicate an interesting point regarding the homotypical relationship of this muscle; for, as in the shoulder, the tendon of this muscle passed from before first upwards and backwards to the coracoidean trochlea, and thence turned backwards and outwards and was inserted into the capsular ligament corresponding to the inner and bicipital side of the great tuberosity; so, in examining the muscles of the hip, we find a corresponding course in the case of the obturator internus, which passes through the lesser ischiatic notch (on the ramus of bone homotypical with the coracoid process), and which, crossing and sometimes united to the capsular ligament, is inserted into the trochanteric fossa on the aspect of the femoral trochanter corresponding to the humeral tuberosity. The difference of origin of these representative muscles can be easily understood, especially if we regard the ilio-pectineal line of the os innominatum as the trace of a sacral rib or hæmal segment united to the basal segment of the lower limb, in which case we may say that the obturator muscle possesses practically a costal origin.

Of the other anomalies presented in this arm there were few of interest; the pronator quadratus was disposed in two strata, the most superficial being the lower, whose tendinous attachment was ulnar, and which overlay the deeper stratum, whose radial attachment was tendinous and whose origin was fleshy. A small band united the flexor profundus digitum with the flexor pollicis longus. The flexor sublimis muscle detached a slim tendon to the little finger, which, crossing that of flexor profundus, was inserted on the outer side of that tendon, and was not split for its transmission. Beneath the origin of flexor sublimis a small pear-shaped muscle arose from the inner condyle of the humerus, and ended in a long tendon which, traversing the palmar region, united with the little finger slip of the flexor profundus opposite the metacarpo-phalangeal articulation in that finger.

In the upper extremities of another female I found the following multiple variations, most of them constant on both sides. 1. A double pectoralis major, in which not only were the clavicular and costal fibres separated, but the latter fibres were in two strata one over the other, and of these the deepest formed the suspensory frænum of Winslow. 2. A small sternalis brutorum on the left side. 3. The biceps was split for more than three-fourths of the arm. 4. A small fleshy fasciculus, about four inches long, dipped from the middle of the deep surface of the biceps, downwards

and backwards, to join the tendon of brachialis anticus. 5. A round muscular band ran from the lower third of coraco-brachialis to the internal intermuscular septum over the brachial artery and median nerve. 6. The coraco-brachialis was much cleft at the point of transmission of the musculo-cutaneous nerve, and had a strong tendinous sling of insertion. 7. The flexor longi radialis arose by a second head from a slip of the tendon of the biceps and from the deep surface of the semilunar fascia, this head being separated from the condyloid origin by the median nerve. 8. A triple insertion of extensor ossis metacarpi pollicis into the short abductor pollicis, the trapezium, and the base of the first metacarpal. 9. The palmaris longus contributed a large fasciculus, which gave an origin to the short abductor pollicis, which latter muscle was bicipital. 10. The inner and deeper portion of the flexor sublimis was digastric, having a central tendon and detaching two fleshy slips inferiorly, which ended in the tendons for the little and index fingers. (A similar arrangement I have met with in the outer part of this muscle, the double-bellied part sending off tendons to the outer pair of fingers. Meckel describes the entire superficial flexor of the loris as being digastric, a condition towards which this seems to be an approach, *Proc. Royal Irish Academy*, Vol. IX. p. 21). 11. The flexor carpi radialis possessed a deep tendinous head from the ulna below the coronoid process, and this was separated from the condyloid origin by the median nerve. This muscle had three origins, one condyloid, one coronoid, and one bicipital, as before-mentioned. 12. A large and distinct subscapulo-capsular muscle was present, and (13) a large pear-shaped coronoid slip to the flexor pollicis longus.

THE PHYSICAL AND PHYSIOLOGICAL ACTION OF MEDICINES.

By WM. MURRAY, M.D. M.R.C.P. Lond. *Lecturer on Physiology in the College of Medicine, Newcastle on Tyne.*

IT is exceedingly dangerous to draw too close a comparison between the action of a living body and an inanimate mechanism, no matter how skilful, delicate, and perfect its device may be. Even as an illustration such a comparison may mislead the unlearned, by giving them to suppose that the likeness goes beneath the surface; for not in appearance only but especially in internal arrangement is the handiwork of man rude and mechanical beside the simplest organism. If, therefore, the thing itself is beyond comparison, we might naturally suppose that the forces operating in and on an organised being could find no counterpart in, or relationship with, the forces by which other machinery is propelled; but this is not so, for the advance of knowledge tends to show that the forces in action are to a great extent the same in the case of the steam-engine and the human body, or in the floating ship and the buoyant bird. The difference lies in the things acted on, *not* in the agents at work; and it lies chiefly in this, that the inanimate mechanism of the one offers a field for the operation of one or two forces which lead to a limited number of results, while the living organization of the other offers a field for the operation of almost all the forces leading to an infinite variety of results.

With these precautions we will venture to illustrate what we mean by "The physical and physiological action of medicines," by comparing their effects in the human organization to what takes place in the working of any piece of skilful mechanism which is affected by the ordinary forces of nature. Let us take an ordinary steamboat for our comparison. In it we have internal arrangement, external device, general configuration, and adaptation to meet the various agencies which may be at hand, and to use

them by affording a field for their operation. By altering any of these parts of the vessel she may be improved or injured, brought up to or allowed to depart from the standard of perfection; and by altering the character of the propelling forces, or external agents, we may obtain similar fortunate or unfortunate results.

The exact adaptation of the vessel in all its parts to those conditions in which it exists for the attainment of certain desired results corresponds to *health;* to disturb these external conditions, or alter the appointments of the vessel, leads to disorder or *disease*, and the extent of such alteration or disturbance is a correct index of the amount of disease produced.

A truly expressed science of medicine will never be produced until we start from these data, and characterize diseases by terms expressive of the exact kind and degree of their departure from the standards of health, nor will the true actions of medicines, or other aids to health, be appreciated till we know how and to what extent they restore these conditions of health. What is wanted is to trace the steps by which medicines proceed to the cure of disease, and see whether that can be discovered which will enable us to say *à priori* what result will follow the administration of a medicine; not because we have learned this from experience, but because we know what kind of action it will produce, and because we know *à priori* that this action will exactly remedy the lesion which exists. From the days of Hippocrates till now we have gone on accumulating mere empirical facts, and in this way we have sometimes managed to cure disease; but to this very day we have failed to ascertain the steps by which our cures were achieved; and medicine will hardly maintain a place among the advancing sciences unless physiology dawns upon her darkness and enables us to see more than the mere beginning and end of what we are doing.

In all sciences there are certain facts which are said to be ultimate; facts incapable of further explanation, and not the result of any combination of simpler forces than that which they themselves express: such a fact is the attraction of bodies to the centre of the earth resulting from or the expression of the force of gravitation. Around all the great forces there cohere a large number of these ultimate facts, and when we have traced anything which occurs in the animal economy to its source in those ultimate actions which rest upon a force whose laws we understand and can test by exact experiment, we have traced it to its origin. In the body, however, we constantly meet with processes which are not in accordance with any known law of physics, chemistry, or physiology; so that we cannot expect to go far in the endeavour to explain the effect of medicine on those processes which are as yet beyond the pale of science. Nevertheless it is our duty to try for an explanation in physical, chemical, and physiological laws, which are known to prevail, and failing here, to wait until these sciences have thrown more light upon the mysterious region of the so-called vital forces.

Seeing that the mysteries of life are every day becoming more evidently resolved into the operation of very simple forces, the prospect of rescuing the action of remedies from obscurity is most encouraging; and it bids us look for very simple explanations instead of shrinking from the effort with awful convictions that no explanation can be given.

Let us try our method on one of our ordinary remedies, and let us take one whose actions have been well observed but never explained. *Calomel*, which I use as a term for any mercurial preparation, effects various changes in the body, and has been called a purgative, a cholagogue, an alterative, general resolvent, deobstruent, &c. &c.

One and all of its actions can however be referred to a series of processes which lead to a rapid passage of fluids through the various membranes

of the body. It acts on the absorbing and secreting surfaces, *effects the passage of fluids from the tissues into the blood through walls of blood-vessels and absorbents,* and it promotes, we aver, the passage of certain nutritive portions of the blood *through the walls of blood-vessels into the tissues.* Bringing the action of this remedy face to face with forces known to prevail in the body, we are struck with the likeness which it bears to the action of the *osmotic forces;* these, by encouraging a mutual interchange of fluids through animal membranes, being pre-eminent in bringing about absorption, secretion, and nutrition. May not calomel act therefore by affording such conditions to the osmosing membranes and fluids as will greatly facilitate their activity? and may not its action be related to the still more complicated series of physical laws which regulate the dialysing properties of these same animal membranes and fluids? conferring upon them not only the power to pass fluids to and fro, but also the power to select what shall and what shall not be disposed of in this way.

From these considerations calomel ought to cause the absorption of material which is deposited in the tissues—and so it does! it ought also to eliminate certain matters from the blood, which it does; and it ought to be a promoter of nutrition, because the passage of matter from the blood to the tissues is another important process dependent on the osmotic and dialytic forces. Is calomel a promoter of nutrition? we affirm it is, whenever the extent to which it induces the passage of nutrient matter into the blood and from the blood into the tissues is not exceeded by the drain of secretions from the blood.

That there are cases in which it thus acts is certain; it often acts as a nutrient in the child by promoting osmose in the right direction, and in the child it seldom acts on the secreting organs to such an extent as to impoverish the blood.

These double actions in contrary directions are at the basis of all osmotic changes, and in their action in the body we see how beautifully osmosis is adapted to maintain the balance of the absorbing and secreting processes. When the osmotic balance is lost we have disease, and when it is restored by medicine (calomel) we have health.

In ptyalism the action of calomel on the bowel is checked, and its osmotic effects thrown upon other secreting organs, such as the salivary glands; the kind of action, i.e. the *direction* of the osmotic current, is, however, the same, for in ptyalism we continually observe the absorption of material from the tissues into the blood. The effect of mercury upon the quantity of fibrin in the blood is not at all adverse to the correctness of our theory; but want of space forbids us to enter on this question here.

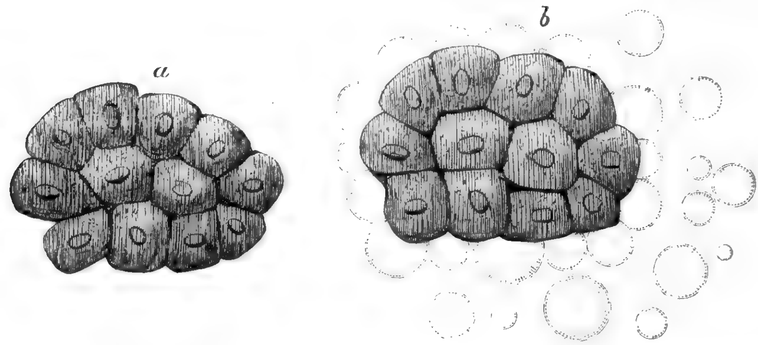
To return to our illustration, we have been doing what the mechanic does when he discovers something which alters the speed of his vessel. He investigates the steps by which the alteration is brought about, and finds it, it may be, in something which causes more carbon to be burned, more heat to be developed, more steam produced, or more pressure to be exerted on the piston. Wherever the cause is found the secret of its operation must be discovered, or he has gained in the result nothing more than an empirical fact applicable to a single case; but when he has discovered the real nature of the result and the steps by which it is produced, how immense have his resources become! This discovery once made enables him to apply his knowledge in a thousand ways hitherto beyond his conception. With the mechanic the steps of his investigation are comparatively easy, but the success attending it calls upon us to follow his example with unwearied exertion. We may accumulate the results of medicinal action for ever without making one-half the advance in our power to heal disease, which would be attained in the thorough understanding of the exact process by which a few of our well-known remedies bring about a cure,—

and we go further still when we discover the forces which are brought into operation by our medicines, especially if we are fully acquainted with the laws according to which these forces act. This reduction of the complicated action of a medicine to the operation of a single well-known process in Physiology or Physics is the aim of our study of the Physical and Physiological action of Medicine.

The above remarks, I am aware, are suggestive rather than demonstrative, and intended to point out the direction which our enquiries may profitably take. I hope to show in a future paper that such enquiries are not in vain.

NOTE ON THE ORIGIN OF HYALINE OR DIAPHANOUS CORPUSCLES. By J. HUGHES BENNETT, M.D. F.R.S.E., &c. Edinburgh.

VARIOUS conjectures have been put forth as to the origin of the hyaline or diaphanous bodies so common in certain organic fluids. Many years ago I pointed out that besides floating loose and presenting variously sized globular corpuscles, they may occasionally be observed to surround pus, blood and other elementary cells, giving rise to the erroneous idea that the latter were produced in the interior of the former. Whether simply deposited around granules and cells as might occur in the yelk of the bird's egg, and in recent pus, or secreted from cells constituting so-called pellucid drops of Mucin or of Colloid matter, was unknown to me until lately. In a woman who died in my clinical ward last summer, labouring under double ovarian dropsy and cystic formations in the omentum, the fluid contents of these cysts were more or less loaded with the hyaline corpuscles, and groups of epithelial cells detached from their internal



walls. On accidentally pressing one of these groups (Fig. *a*), when manipulating the covering glass, I saw under the microscope numerous diaphanous bodies start out from its circumference, some of which remained adherent when the pressure was removed, whilst others floated loose, and assumed a perfectly globular form (Fig. *b*). It is clear therefore that under certain circumstances the diaphanous bodies are given off from cells. It is further probable that when such viscous albuminous matter is seen surrounding pus-cells and agglomerations of blood-corpuscles, it also transudes from their interior. How far the observation now detailed may serve to explain the production of cell-walls rising from a nucleus, like the glass from the dial of a watch, as originally described by Schwann, further investigation can alone determine.

ON THE PHYSIOLOGICAL ACTION OF THE CALABAR BEAN (*Physostigma venenosum*, Balf.). By THOMAS R. FRASER, M.D. F.R.S.E. Assistant to the Professor of Materia Medica in the University of Edinburgh.

THE peculiar actions of Calabar Bean on the pupil and on vision have been investigated by nearly all the leading ophthalmologists of Europe and of America, but the general physiology of this substance has occupied the attention of comparatively few observers. The results obtained by the latter have been discordant, and, therefore, many of their conclusions are of necessity erroneous. This investigation was undertaken for the purpose of establishing and supporting the opinions I published on this subject in 1863. The leading results obtained at that time were that Calabar Bean causes death by either asphyxia or syncope; that the former is due to an effect on the spinal cord and on the respiratory centres; and that the symptoms resemble those of syncope or asphyxia according to the quantity of poison administered and to its rate of absorption[1].

The actions on the pupil and on vision will be merely alluded to, as this portion of the subject has not been completed. Enough has, however, been done to convince me of the insufficiency of the views hitherto advanced and to suggest the advisability of extending my observations.

To Professor Harley, of London, we are indebted for several very able papers on this subject. The principal conclusions at which he arrived were, that Calabar Bean paralyses the motor nerves and so causes death by asphyxia, and that, while it may weaken the heart's power, it neither stops the circulation nor arrests the heart's action: in fact, that the mechanism of death by Calabar Bean is very much the same as that by either curare or conia[2]. The result of my investigations obliges me to express my non-concurrence with Dr Harley's conclusions. Calabar Bean causes death by asphyxia; but the most careful examination has failed in shewing me that this asphyxia is due to a paralysis of the motor nerves. In more than one hundred and twenty experiments in which I tested the condition of these nerves immediately after death, stimulation, whether galvanic or by means of dilute acids, invariably gave evidence of their continued activity; and I have never found that the motor conductivity has been destroyed until a considerable interval has elapsed since the arrest of the respiratory movements. Dr Harley alludes to an experiment on a rabbit, in which he tested the condition of the motor nerves, but he does not, unfortunately, mention how long after death his examination was made[3]. I have found that the interval during which they remain active varies greatly in different animals, and in the same animal according to the dose of poison administered. In the rabbit, motor conductivity may be retained for periods ranging from four to thirty-one minutes, and it may be lost within eight minutes after the autopsy was commenced, which was never done, in these experiments, until a few minutes after respiration had ceased. A distinct but short period has always occurred in dogs and rabbits, and a much longer one in frogs, in which it was unimpaired. I am inclined to account for this misstatement on the part of so acute an observer, by supposing that the examination of the motor nerves had not been made *very soon* after death.

We must, therefore, look to other causes for an explanation of the asphyxia which is sometimes produced. An examination of the diastaltic

[1] On the Characters, Actions and Therapeutic Uses of the Ordeal Bean of Calabar, *Edin. Med. Journal*, 1863; and Pamphlet. Graduation Thesis, 1862.

[2] *Journal de l'Anatomie et de la Physiologie*, 1864, p. 141 et seq.

[3] *Op. cit.* p. 151.

function of the spinal cord confirms, in the most satisfactory manner, the opinion which I originally expressed, that this symptom is caused by an effect on the spinal cord, of such a nature as to weaken and then to destroy its reflex function.

Experiment I. A frog was suspended by its lower jaw and the reflex activity tested by dipping the web of both posterior extremities in dilute sulphuric acid (11 min. oil of vitriol to 12 oz. of water). The exact time which elapsed between the contact of the foot and the resulting reflex movement was ascertained by the beats of a métronome, set at one hundred to the minute. Before the administration of the poison the reflex movement occurred in twelve beats. A large dose of extract of Calabar Bean was injected into the abdomen.

In 5 minutes	reflex movement occurred in	15	beats.
... 10	... ...	31	...
... 15	... ...	40	...
... 20	... ...	57	...
... 25	... ...	69	...
... 30	... ...	82	...
... 35	... ...	106	...
... 40	... ...	134	...
... 45	... ...	165	...
... 50	... ...	181	...
... 55	... ...	192	...
... 1 hr. 5 m.	no reflex movement after	250	...
... 1 hr. 15 m.	strong acid caused no movement.		

The sciatic nerves were then exposed, and weak and carefully localized galvanism applied to either trunk caused energetic contractions of the limb below the portion stimulated, and these contractions could be obtained for two hours after the injection of the poison.

While denying that the asphyxia produced by Physostigma results from any implication of the peripheral motor apparatus, I admit that this poison exerts a special action on these nerves. Motor conductivity is lost more rapidly, in mammals and birds, than after death by agents or means which do not affect these nerves. We can in frogs definitely prove this action if we protect a portion of the animal from the poison by ligaturing the blood-vessels of a limb.

Experiment II. The right iliac artery and the right ischiadic vein were tied in a frog, weighing six hundred and twenty grains, and five grains of alcoholic extract of Physostigma, suspended in thirty minims of distilled water, were injected into the abdominal cavity. In twenty minutes, voluntary movements had completely ceased, there were no respirations, and the frog lay in a perfectly flaccid condition. Fifty minutes after the administration of the poison, the left sciatic nerve was exposed: very weak galvanism of the nerve-trunk caused contractions of the limb, and continued to do so, on occasional observations, till two hours and ten minutes from the commencement of the experiment, or until fifty minutes after the respirations had ceased. It was, however, found to be completely paralysed in other fifteen minutes, or in two hours and twenty-five minutes after the poison was injected. The right sciatic nerve, which had been protected from the influence of the poison by ligature of the blood-vessels of the limb, was examined in a similar manner. *Its motor canductivity continued unimpaired for at least five hours longer than that of the poisoned nerve.*

This is merely an example of numerous experiments which were undertaken for the special purpose of examining this effect of Calabar Bean. From this experiment it can also be shewn that the endorgans of the motor nerves are paralysed before the nerve-trunks. If, after a stimulus, applied to any portion of the nerve of the *poisoned* limb, is followed by no muscular contractions of that limb, we place our electrodes on the nerve of the *non-poisoned* leg above the portion ligatured (that is, where the poison had access to the nerve-trunk), contractions will follow as readily as when these are placed below the ligatures (that is, where the nerve terminations were not poisoned). This result may be confirmed by protecting the endorgans only from the poison, as by ligaturing the vessels of the gastrocnemius, when the muscle supplied by the protected endorgans will alone contract on stimulation of the nerve-trunk.

Dr Harley denies that death ever results from syncope after the administration of this poison. In a former publication I have given details of a most satisfactory description, in which Calabar Bean caused death by its action on the heart[1], and my facts are supported and confirmed by other observers[2]. Until good cause can be shewn to discredit these observations, something further than a mere statement, unaccompanied by proof, is required to support Dr Harley's opinion. It would, therefore, prolong this paper in a very unnecessary manner were I to re-narrate the evidence on this point, or to state the many confirmatory experiments I have since made. It will be sufficient to shew that no connection of cause and effect necescessarily exists between the impaired respiratory movements and the cardiac paralysis.

Experiment III. In a large retriever dog it was found that the mean number of respirations was ten, and the mean number of cardiac contractions one hundred and twenty-six, during seven minutes immediately preceding the injection of six grains of extract suspended in water, into the right jugular vein.

1 min. after the injection	the respirations = 10,	cardiac contractions = 78 per min.
1 ... 30 sec. ...	= 11,	= 54 ...
2 ... 0 ...	= 9,	= 40 ...
3 ... 0 ...	= 9,	= 8 ...
7 ... 0 ...	= 10,	= 20 ...
9 ... 0 ...	= 10,	= 16 ...
10 ... 0 ...	= 9,	= 9 ...
10 ... 30 ...	= 0,	= 0 ...

This experiment gives the result that, in one minute and thirty seconds after the poison was administered, the cardiac contractions had fallen to less than one half, while the respiratory movements had increased by one per minute, and it distinctly shews the absence of any respiratory change to cause the marked effects which were produced on the heart's action.

Experiment IV. A frog, weighing 460 grains, had its heart exposed by removing the sternum. It was acting at the rate of 48 beats per minute, while the respirations were 72. Five minutes afterwards, the heart was contracting at the rate of 45 per minute, while the respirations were 74. One grain and a half of extract suspended in water was injected by Wood's syringe under the skin of each thigh (three grains in all).

Time	Heart		Respirations
In 5 min.	= 36 per min.		= 74 per min.
... 10 ...	= 28 ...		= 64 ...
... 15 ...	= 22 ...		= 63 ...
... 20 ...	= 14 ...	weak, and continues dark during systole.	= Frequent gasping movements which cannot be counted.
... 25 ...	= 13 ...		
... 30 ...	= 12 ...		= An occasional gasp.
... 40 ...	= 10 ...		Respirations have stopped.
... 50 ...	= 10 ...		
... 1 hr. 0 ...	= 8 ...	very feeble.	
... 1 ... 10 ...	= 8 ...		
... 1 ... 15 ...	= 0 ...	stopped in diastole.	
... 1 ... 20 ...	= 0 ...		
... 1 ... 30 ...	= 12 ...		
... 1 ... 40 ...	= 12 ...		
... 1 ... 50 ...	= 12 ...		
... 2 ... 0 ...	= 10 ...		
... 2 ... 30 ...	= 8 ...	irregular: two auricular for one ventricular.	

The heart continued to act in an irregular manner for at least eight hours after the injection, when the observations were stopped.

These experiments prove distinctly that Calabar Bean has a direct influence on the heart, which is quite independent of the indirect influence which it may exert on this organ by arresting the respiratory movements. I think the evidence I have given is sufficient to shew that Dr Harley has

[1] *Op. cit.* Experiments 3, 6, 11, 14, 15, 26.

[2] Christison, *Monthly Medical Journal*, Vol. xx. 1855. Nunneley, *On the Calabar Bean, &c.* 1863, p. 23. Pamphlet. Von W. Laschkewich. Virchow's *Archiv*. Februar. 1866.

to an important extent misinterpreted the phenomena which are produced by Physostigma.

Mr Nunneley, of Leeds, has made an interesting series of experiments with Calabar Bean[1]. He appears to consider that its effects are principally due to a special action on the heart, but he admits that the dose and mode of administration of the poison may so far modify its effects as to cause symptoms of either syncope or asphyxia. I cannot agree with Mr Nunneley in his further statement, that both these results are caused by a common action of Physostigma on the heart and on voluntary muscles. In maintaining that general muscular contractility is lost, Mr Nunneley occupies a position which is contradicted, as far as I know, by every writer on this subject, and his statement is unsupported by any observation which he has published. Far from this being the case, one of the very last symptoms of vitality is the retained idio-muscular contractility. The voluntary muscles always contract long after motor nerve-conductivity has been destroyed, and, in frogs, I have seen distinct muscular action produced by galvanic stimulation five days after the administration of a poisonous dose. In this respect it causes an analogous effect to curare[2], for while in parts separated by ligature muscular contractility is lost within three days, in the poisoned parts it may be retained for two days longer.

Dr Anstie has done me the honour of criticising that portion of my former publication on this subject which refers to the pupil changes produced by the constitutional action of Calabar Bean, in his able and original work on *Stimulants and Narcotics.* As I have already indicated my intention of returning at a future opportunity to this branch of the investigation, I merely, in courtesy to that distinguished observer, wish to refer to one statement which he has made. It is to the effect that Physostigma does not cause contraction of the pupil "when the blood is fully poisoned with it; that it is only the slighter influence, which can alone be produced on iridal movements by local application which causes contraction;" and that "a dose of the bean (taken internally) such as is sufficient to produce acute general poisoning falls with destructive force upon the sympathetic system, producing paralysis of the heart, and dilatation of the pupil[3]." I hope to be able to discuss the theories involved in these assertions on a future occasion, but, as I believe the facts are erroneous, and as they are contradicted in my conclusions, I take this opportunity of stating some of the evidence bearing on them. I find that in twenty-five of my experiments, in which the effects were produced by internal administration, the condition of the pupil was carefully noted, with the results given in the adjoining table.

In many other experiments the pupils are described as having contracted during the poisoning, but the exact changes were not measured. In two or three out of more than a hundred, the pupils are said to have been dilated at the time of the observation. It is possible that this dilatation had not been preceded by a stage of contraction, but I prefer to believe that the examination happened to have been made when the latter had given place to dilatation. In the Table, Experiments 46, 49, 81, 96, 99 and 110 illustrate the occasionally rapid change from contraction to dilatation, and, unless special and continued attention be directed to the condition of the pupils, it is obvious that contraction will frequently escape detection. Harley[4], Amédée Vée[5], Nunneley[6], Laschkewich[7], and van

[1] *Op. cit.* and *Lancet*, 1863.
[2] Claude Bernard, *Leçons sur les effets des Substances Toxiques*. 1857. p. 320.
[3] *Stimulants and Narcotics.* By Francis E. Anstie, M.D. &c. 1864, p. 481.
[4] *Op. cit.* p. 140.
[5] *Recherches sur la Fève du Calabar.* 1865. p. 22, &c.
[6] *Op. cit.* p. 12.
[7] *Op. cit.* p. 300.

TABLE OF PUPIL-CHANGES DURING POISONING BY PHYSOSTIGMA[1].

Experiment.	Animals.	Average before poisoning.	Minimum after poisoning and time of occurrence.	Time of return to average before poisoning.	Dilatation over average and time of occurrence.	
No. 6	Frog	3×4[1]	1·75×3 in 46 m.	Not noted	None noted	
,, 28	do.	5×7	4×5 in 29 m.	4 hrs.	,,	
,, 37	do.	5×7	4·5×6 in 16 m.	55 min.	6×7 in 1h. 10m.	
,, 38	Rabbit	13 (long. diam.)	4 in 7 m.	Not stated	None noted	
,, 42	do.	9 ,,	4 in 5 m.	15 min.	,,	
,, 43	do.	10 ,,	7 in 11 m.	23 min.	,,	In 23 m., when the pupil had returned to its average, the animal had nearly recovered from a small dose: the second line marks the effects caused by another and larger dose, given 24 m. after the first.
,, ,,	,,	10 ,,	6 in 7 m.	Not noted	,,	
,, 44	do.	10 ,,	3 in 12 m.	,,	,,	
,, 45	do.	11 ,,	3 in 16 m.	58 min.	,,	
,, 46	do.	9 ,,	3 in 7 m.	8 min.	,,	
,, 47	do.	12 ,,	4 in 8 m.	Not noted	,,	
,, 48	do.	13 ,,	3 in 8 m.	,,	,,	
,, 49	do.	11 ,,	3 in 16 m. 30 s.	17 m. 30 s.	,,	
,, 50	Frog	4×6	3·5×5 in 24 s.	Not noted	,,	
,, 53	do.	5×6	4×5 in 25 s.	2 hrs.	5×6 in 1h. 46m.	Eyelids closed, and difficult to see pupil after 24 m.
,, 73	do.	5×6	3×4·5 in 16 s.	2 hrs.	None noted	
,, 76	do.	5×6	4×5 in 30 s.	1 hr. 47 min.	,,	
,, 81	Dog	21	17 in 28 m.	29 min.	25 in 30 m.	
,, 82	Frog	5×6·5	4×5 in 19 m.	2 hrs. 5 min.	None noted	
,, 83	do.	4×5·5	3·5×5 in 11 m.	22 min.	None noted	
,, 85	do.	6×7·5	3×5 in 50 m.	Not noted	,,	
,, 96	Dog	21	15 in 4 m.	4 min. 30 sec.	25 in 5 m. 30 s.	
,, 99	do.	10	4 in 5 m. 30 s.	8 min.	15 in 10 m.	
,,110	do.	16	3 in 7 m.	9 min. 30 sec.	None before death	
,,115	Pigeon	6	4 in 8 m.	Not noted	None noted	
,,116	do.	6	4 in 28 m.	Not noted	,,	General symptoms very slowly produced.

Hasselt[2] agree in describing contraction of the pupils as one of the effects which follow the internal administration of Calabar Bean.

Dr Laschkewich of St Petersburgh has recently published an elaborate investigation, and has, in a most satisfactory manner, confirmed my results. The conclusions which this physiologist has arrived at are :—1. Calabar Bean affects the spinal cord, and so produces a general paralysis. 2. It also paralyses the heart. 3. Division of the nervi vagi does not prevent the heart from being influenced. 4. Calabar Bean causes contraction of the pupils either by topical application or by action through the blood. 5. It increases the flow of saliva and of tears. 6. The sympathetic nerves and intestinal muscles are paralysed by Calabar Bean. 7. The peripheral nerves, the muscles of the body, and the brain are not affected. 8. When the poison was put directly into the blood, death followed by cardiac paralysis; but when it was injected under the skin (i.e. by slow poisoning) death was caused by asphyxia.

The sixth and seventh of these conclusions are not strictly in accordance with my results. On the former, I must refer to the 14th and 19th of the general conclusions at the end of this paper; and, on this point, I have the support of so trustworthy an observer as Professor Donders[3]. Dr Laschkewich has evidently overlooked the paralysis of the motor endorgans by restricting his examination to the question of how far the motor nerves are concerned in the production of the general paralysis. Finding that

[1] The figures represent fiftieths of an inch: the measurements were made with a glass scale each division of which equalled the one fiftieth of an inch.

[2] Quoted by Donders (Accommodation and Refraction of the Eye: New Sydenham Soc. 1864) as having been observed in 1856, and, I am informed by Prof. Donders, communicated to a scientific society, but not otherwise published by van Hasselt.

[3] Accommodation and Refraction of the Eye: New Sydenham Society, p. 616.

the peripheral motor apparatus was unaffected when the respiratory movements had ceased, he appears to have considered the question as decided; whereas, a further examination, especially by limitation of the poisoning, would have given unmistakeable evidence of the action of Physostigma on the terminations of the motor nerves.

In the investigation, of which the conclusions will now be given[1], an extract, prepared by acting on the finely pulverized kernel with boiling alcohol (85 p. c.), has been used. This preparation contains a considerable proportion of fatty matter, which prevents its perfect solution in water; and, as the division into separate doses of a mere watery suspension would lead to many inaccuracies, it was found necessary to weigh the requisite quantity separately for each experiment. This extract is hygroscopic, which further required that it should be dried and kept in an exsiccator. The majority of the experiments were made with the common frog (Rana temporaria), birds, and various mammals. It was found that fatal results were produced with the smallest quantity on birds, and that the largest doses, in proportion to weight, were required by amphibia. A dose of one-sixteenth of a grain proved rapidly fatal to a pigeon, whereas three grains have been recovered from by a frog—a quantity sufficient to produce death in a dog of average size.

The following are the conclusions of my investigation.

A. *Action through the Blood.*

1. Physostigma proved fatal to every animal hitherto examined, with the exception of the Esĕrĕ moth[2]. Death is most rapidly caused, in birds and mammals, by the injection of the poison into the circulation, or when it is brought in contact with a wounded surface. It follows, nearly as quickly, when Calabar Bean is introduced into a serous cavity, and, much less rapidly, when introduced by the mucous membrane of the digestive system. In rabbits, death has been caused by its application to the Schneiderian, auditory, and conjunctival mucous membranes. The skin of frogs resists its effects for a long time; but, if applied for a sufficient period and with proper precautions, distinct evidence of its absorption may be obtained, though death has never been caused by such application.

2. The contact of the extract of Calabar Bean with the gastric juice of a dog for twenty-four hours, at a temperature a little above 95° F., did not, in the slightest degree, modify its energy.

3. A large dose, given to a mammal or bird, rapidly affects the cardiac contractions, and then paralyses the heart. The respiratory movements are quickly stopped, but the symptoms and *post-mortem* appearances are those of syncope. Such a dose, injected into the abdominal cavity of a frog, affects nearly simultaneously the heart and spinal cord[3], and very rapidly destroys the vitality of both organs. With such a dose the motor nerves are unaffected, and retain their conductivity for at least thirty hours. Evidence of the vitality of the afferent nerves may be obtained so long as the retained vitality of the spinal cord permits of its diastaltic function being examined.

4. An average dose produces symptoms of asphyxia in mammals and birds. When administered to frogs, a similar dose impairs the function of the spinal cord, and diminishes the rate of the cardiac contractions and of the respiratory movements, and, soon after, the latter cease. In periods,

[1] The investigation, from which these results are derived, has been laid before the Royal Society of Edinburgh, and an abstract is published in the Society's *Proceedings* for 1867.

[2] *The Annals and Magazine of Natural History.* Vol. XIII. 1864. p. 389.

[3] The effects on the spinal cord were determined by frequent measurements of the reflex activity by means of a métronome.

varying from one and a half to four hours afterwards, the motor nerves are paralysed; this paralysis first implicating the endorgans of these nerves, and afterwards the nerve-trunks. From this it must not be inferred that the nerve is paralysed by a centripetal progression of the poison, the only fact which was demonstrated being that a direct ratio existed between subdivision of nerve substance and facility of contact of poison, on the one hand, and, on the other, rapidity of paralysing effect. Indeed, division of the nerve-trunk, previous to the administration of Calabar Bean, delayed the paralysis of its endorgans. The afferent nerves retain their activity so long, at least, as the functions of the spinal cord are not lost, and this generally happens about the same time as the motor paralysis.

5. When a small, but still fatal, dose of Calabar Bean is administered to a frog, the effects are the same as those in the previous conclusion, until they arrive at the stage of paralysis of the motor nerves, and, after this, an interval of several hours may elapse before the functions of the spinal cord are completely suspended. During this interval the *tactile* sensibility of the afferent nerves is increased; so that, if the ischiadic artery and vein of one limb were tied before the exhibition of the poison, an ordinary excitant, such as sulphuric acid, will show everywhere a marked diminution in the diastaltic activity, as measured by the métronome; while a slight touch of the skin in the poisoned region, which before the administration of the poison caused no effect, will now produce faint twitches of the limb whose vessels are tied.

6. *A frog may have its cardiac contractions reduced from seventy to eight per minute, its respiratory movements completely stopped, and the endorgans of its motor nerves paralysed, by a still smaller dose, and afterwards completely recover.* This has occurred when two grains were injected into the abdominal cavity of a frog, weighing seven hundred and thirty grains.

7. In frogs the voluntary muscles are unaffected by the poison, and may continue to respond to galvanic stimulation during three or four days after its administration. The contrast and independence in the effects of Calabar Bean on the motor nerves and on the muscles may be well shewn by ligaturing the ischiadic vessels of one limb before injecting the poison. If, when strong stimulation causes no reflex movement, the two gastrocnemii muscles with their attached nerves are so placed that an interrupted current, from one Daniell's cell and Du Bois Reymond's induction apparatus, may be transmitted simultaneously, either through both muscles or both nerve-trunks, it will be found, in the case of the muscles, that when the secondary coil is slowly advanced contractions will occur with the same current in both muscles, or with a weaker current in the case of the poisoned than of the non-poisoned muscle, this varying with the length of time which has elapsed since the limb was deprived of blood; when the current is transmitted through both nerves, contractions will be simultaneously produced, or with a weaker current in the non-poisoned, or contractions will occur in the non-poisoned muscles only, this also varying with the length of time which may have elapsed since the exhibition of the poison.

8. In mammals and in birds the voluntary muscles are affected in a very remarkable manner. At an early stage of the poisoning, faint twitches occur, which gradually extend over the body, and, at the same time, increase in vigour so as to interfere with the respiratory movements. Shortly before death they again become mere successive twitches, often requiring the hand to be placed over the part to discover their existence. After death, if a muscular surface be exposed, these twitches will still be observed, rarely involving the whole of one muscle, but at different times different muscular fasciculi; and in mammals they may persist for more

than thirty minutes after death. They are caused by a direct effect of Physostigma on the muscular substance. This is shewn by their continuing after paralysis of the motor nerves, by their persisting in a muscle cut out of the body, and by their non-occurrence in parts which have been separated by ligature from the circulation.

9. The heart's action is rapidly made slower and then stopped, in birds and mammals, by a large dose. In dogs it may diminish to one-half in three minutes, and cease in ten. A large dose injected into the abdominal cavity of a frog causes rapid and complete cardiac paralysis. A smaller dose causes either a gradual cessation and then a renewal at a diminished rate, or a gradual fall from sixty or seventy to four or six beats per minute, followed by a gradual return to a diminished rate of eight or twenty per minute. At this stage, and for many hours afterwards, the only signs of vitality are this diminished cardiac action and the power of the voluntary muscles to respond to galvanic and other stimulation. In the frog, where alone these last phenomena have been observed, the heart may continue so to contract for three, and for even five, days, provided the temperature of the apartment be as low as 50° F. After stoppage, galvanism may cause a renewal of its rhythmical contractions; but this can rarely be done, and unrhythmical and partial contractions can only be excited. The heart ceases to contract in diastole, with all its chambers full.

10. The pneumogastric nerves retain their inhibitory power over the heart during the whole time from the diminution to the partial recovery of its action. Soon after this, however, they are paralysed; and this occurs at nearly the same time as the affection of the motor nerves.

11. Division of the pneumogastric nerves, or their previous paralysis by curare, or destruction of the medulla oblongata or spinalis, does not protect the heart from the action of Physostigma.

12. The lymphatic hearts of frogs poisoned by Calabar Bean soon cease to contract.

13. A large dose paralyses the cervical sympathetic nerves, in rabbits, before the death of the animal. A smaller fatal dose diminishes, without destroying, their activity.

14. Before the stoppage of the heart, proofs may be obtained of the vitality of its sympathetic ganglia; but, as striped muscle is not affected by Calabar Bean conveyed by the blood, we are obliged to infer, from the symptoms respectively produced, that the activity of the cardiac sympathetic system may be destroyed by a large dose, and lessened by a smaller one.

15. The animal temperature, both external and internal, has been invariably observed to rise in rabbits and dogs, but only slightly.

16. The condition of the capillary circulation was examined in the web of the frog. Soon after the exhibition of the poison the smaller arteries and veins contracted slightly; after a short interval, this contraction was succeeded by a rapid and permanent dilatation, in which the calibre of the vessels was considerably above their maximum previous to the poisoning. This capillary dilatation appears to occur over all the body, as is shewn by a peculiar blue coloration of the voluntary muscles and of the heart, a similar coloration of the serous and fibro-serous tissues, and a congestion of the blood-vessels in the conjunctiva and iris. This change also occurs, in a less marked manner, in birds and mammals.

17. The general results of experiments in which the arterial and venous tensions were examined were, that almost immediately after the administration of Calabar Bean the arterial tension rose slightly, attained its maximum when the number of cardiac contractions had diminished to at least one half, and, then, rapidly fell; and that the venous tension rose

less quickly, attained its maximum when the arterial tension had considerably diminished, and, in its turn, fell, though more gradually than that of the arterial system. The number of the cardiac contractions, when the venous tension had attained its maximum, was about one-third of the average before the poisoning; the respirations were rather less frequent than before; and the temperature had risen a few tenths of a degree.

18. Physostigma causes extreme diffusion in the pigment cells of the frog's skin, and, so, a very marked change occurs in the colour of the animal during the progress of the symptoms.

19. In dogs, the peristaltic action of the intestines is usually destroyed at death; it may, however, continue a short time afterwards. In rabbits, the intestinal movements are frequently increased in activity before death, and they generally continue for a considerable time afterwards.

20. The pupil contracts in all cases of rapid poisoning in mammalia and in birds. The contraction may, however, be slight and of short duration, and dilatation may then be observed during the greater portion of the experiment, especially if the dose be a small one. The same effect is produced in frogs.

21. Calabar Bean acts as an excitant of the secretory system, increasing the action of the alimentary mucous, of the lachrymal, and of the salivary glands.

22. The symptoms of poisoning are not materially altered, in the frog, by removal of the brain, or by division of the cervical portion of the spinal cord.

23. Artificial respiration does not prevent death, in mammals, after the exhibition of a poisonous dose. This is a necessary result of the effects of Physostigma on both the cerebro-spinal and sympathetic systems.

24. Congestion of internal organs occasionally occurs, but this is by no means an invariable consequence of a fatal dose.

25. The blood is dark after death, but becomes arterialized on exposure to the air; its respiratory functions are unaltered; it often clots loosely and imperfectly; and, when examined with the spectroscope, the bands of scarlet crurine are found unchanged. A microscopic examination demonstrates, in the rabbit and dog, an invariable change in the coloured corpuscles which have their outlines distinctly crenated. This change is not observed in the blood of birds or of amphibia. The white corpuscles remain unaltered.

B. *Topical Effects.*

1. When applied to the surface of a frog's brain no effect is produced; but when the poison is brought in contact with the spinal cord, a few twitches occur in the extremities, followed by paralysis of the portion of cord acted upon.

2. When physostigma is applied to a mixed nerve-trunk, in a concentrated form and with proper precautions to prevent absorption, the afferent nerve-fibres are first paralysed, and, afterwards, the efferent.

3. Topical application destroys the contractility of striped and of unstriped muscular fibre. The heart's action is stopped by repeated application to its external surface or to the pericardium. If a small quantity be injected into one of its chambers, paralysis nearly immediately follows.

4. The effects of the application of Calabar Bean to the eye-ball are a somewhat painful sensation of tension in the ciliary region, contraction of the pupil, myopia and astigmatism, congestion of the conjunctival vessels, pain in the supra-orbital region, and twitches of the orbicularis palpebrarum muscle.

Many of these physiological results indicate therapeutical properties of great value, and several of these have been already pointed out in my first

paper on this subject[1]. The unmistakeable success which has followed the recommendation that was there made to employ Physostigma in the treatment of tetanus, first, under M. Giraldès, of Paris, and, very recently, in the hands of Dr E. Watson, of Glasgow[2], encourages me to hope that this substance will prove even more valuable to the physician than to the ophthalmic surgeon.

OBSERVATIONS ON BRITISH ZOOPHYTES AND PROTOZOA.

By T. Strethill Wright, M.D., &c.

(*Plates* XIV. and XV.).

1. *On Stomobrachium octocostatum* (Forbes).

Stomobrachium octocostatum (Forbes) is occasionally found in the Firth of Forth, in the neighbourhood of Queensferry, and Granton. All the specimens of this animal which I have taken have been females, and as Stomobrachium is one of those medusæ which feed and thrive well in captivity, I have repeatedly endeavoured to obtain young zoophytes from it in the hydroid stage of their existence, but hitherto without success, as the development of the ova in the ovarian bands invariably became arrested soon after the animals were removed from the sea. I have little doubt, however, that the hydroid phase of Stomobrachium will eventually be obtained, and that it will be a Tubularian polyp, allied to Atrachylis or Clavula, inasmuch as its medusoid form is destitute of otolithic sacs, organs which have hitherto been found always absent in the medusoids of Tubularian zoophytes. Several years ago I accidentally noticed such a hydroid, as a single, minute, yellowish polyp, resembling Clavula, and having three rows of filiform tentacles, attached to a stone in a large tank, in which a specimen of Stomobrachium was confined with some other zoophytes, but I was not able to establish any connection between the polyp and the medusa, as the planuloid larvæ of the latter were not ripe for extrusion, and never became so, although the medusoid lived for several weeks.

On examining a specimen of Stomobrachium last summer, which had been recently fed on the whiter parts of an oyster, I noticed a retiform system of fine canals, Fig. 1 *a*, *a*, *a*, permeating the muscular web of the sub-umbrella and altogether distinct from the eight large lateral canals which carried the ovarian bands. This new canal system consisted of from three to five fine tubes, which sprung from the upper margin of the peduncle, between each of the lateral canals, and passed outwards and downwards as a rarely anastomosing network, to join the circular canal bordering the mouth of the umbrella. No branches from it communicated with the lateral canals, nor could they do so as the latter were bordered on each side by the long ovarian bands.

Throughout the whole supplementary system the presence of ciliary action was indicated by the vibratory and onward movement of the milky fluid contained therein, and it is evident that the function of this system is to supply nutrient material to the powerful muscular tissue of this rapidly swimming medusa.

As far as I know, no similar canals have been detected in any of the Gymnopthalmatous medusa. In Willsia the peripheral extremity of the lateral canals is branched, but this must not be confounded with the separate system I have described above.

[1] *Op. cit.* Sect. IV.

[2] *Lancet*, March 2, 1867.

2. *Note on the mode of observing the reproduction of Zoophytes.*

In observing the reproduction of a naked-eyed medusæ, the greatest care must be taken that the sea-water used in the experiment is perfectly free from the presence of the planuloid larvæ of other forms, which are frequently contained in water recently brought from the sea. The water must be slowly passed through filtering paper into a glass vessel capable of containing not less than three or four gallons, in which are placed a few fronds of *Chondrus crispus* or *Enteromorpha.* A few of the medusa only should be placed in the vessel, amongst which it is advisable, but not necessary, that one should be a male with white and opake, not transparent, spermatic sacs. The animals should be frequently fed with minute pieces of mussel or oyster.

As soon as the planulæ appear they should be removed with a dipping-tube into a round glass shade inverted and filled with sea-water from the larger vessel, to which a few drops of mussel-juice must be added daily until it appears crowded with minute protozoa to serve as food for the future hydroids. The internal surface of the shade, and the surface of the water, should be examined often from without with an inch lens, and as soon as each planula adheres to the inside of the glass, a thin disc of microscopic glass should be attached externally over its site with an interposed drop of glycerine, to ensure a flat surface, and the microscope, placed on a proper support, should be brought up to it armed with a power of about eighty diameters. The light, the quantity of which must be regulated by a diaphragm of blackened card or metal, should be reflected from a plane mirror, and carefully adjusted so as to pass through the water directly in the axis of the tube of the microscope. By this means the whole development of the planula into the hydroid zoophyte, with the successive development of the polypary, and the budding of the polyps, may be seen in a very beautiful manner. These processes are carried out in periods varying greatly with the genera and species of zoophytes from which the planulæ are derived. Thus in Sertularia pumila and Campanularia dichotoma the first young polyp is complete in its polypary in a few hours after the planula is discharged; while in Æquorea and Hydractinia our patience is tried for several weeks ere the same event occurs.

When the reproductive process has to be examined in very large medusa, whether of the Gymnophthalmatous or Steganophthalmatous type, such as Æquorea Chrysaora, Cyanea and Aurelia, the planulæ may be removed from the ovaries or the marsupial sacs of the Medusæ as they lie exposed on the shore, and rarely fail to become developed into polyps or Ephyræ. The Ephyræ of the Steganopthalmata remain in the polyp phase of their development for many years, if well fed and kept in a darkened place, and multiply rapidly by gemmation. They may, however, be forced to assume their medusoid state, by exposing them without food in a small quantity of sea-water, to direct sunlight.

3. *On Acanthobrachia inconspicua* (nov. gen. spec.), T. S. W. (Fig. 2.)

Umbrella hemispherical, laterally compressed. Peduncle four-lipped, short. Lateral canals, four. Tentacles eight; six long, springing from the sides of the margin of the compressed umbrella; two abortive, placed at each end of the umbrella. Otolithic sacs eight, two accompanying each of the tentacular bulbs, which do not correspond to the lateral canals. Extremities of tentacles furnished with large prehensile palpocils.

This zoophyte, which, inasmuch as it is furnished with otolithic sacs, is, doubtless, the reproductive phase of a Campanularian zoophyte, was found in Granton Harbour in the summer of 1862. It is remarkable for the lateral compression of its umbrella, the *circular* marginal canal of

which presents an oval contour, and for the bilateral structure which the animal otherwise presents. The tentacles placed at each end of the oval are very short, and attached by one side along the border of the canal, nearly as far as one of the neighbouring otoliths, as in Plate XIV, figs. 2 and 3*a*. The long lateral tentacles, which are capable of being extended to twelve times the depth of the umbrella, are distinguished by the long soft spinous palpocils (fig. 4) which spring from their sides, and which are capable of being protruded from the ectosarc (*ectoderm* Allman), and of adhering with singular tenacity to any object or smooth surface with which they come in contact, over which they spread themselves out in an irregular discoid state, so that the animal can hang by its tentacles to the sides of the vessel in which it is confined. I have noticed the existence of similar exaggerated on the tentacles of a Gymnopthalmatous medusa in my paper on *Goodsirea mirabilis*. In both Goodsirea and Acanthobrachia they are entirely independent of the existence of thread-cells, which bodies are absent on those parts of the tentacles from which the palpocils spring.

The *palpocil* has been erroneously considered as part of the thread-cell, with which it is frequently associated both in zoophytes and annelids. In my paper on Hydractinia I have described the palpocil as a protrusion of the homogeneous and granular ectoderm, and homologous with the prehensile processes of Actinophrys; and in different orders and genera of zoophytes the shape of the palpocil resembles the same processes in various animals allied to Actinophrys. Thus, on the bodies of the polyp of Coryne and on the lower whorl of tentacles in the polyps of Stanridea producta, they resemble exactly the minute palpocil of Zooteireas which are found growing on the horny polypidoms of the latter. In Hydra and the strange pyramidal planulæ of Hydractinia, which creep along erect on their basis, they approach to those of Actinophrys. In Acanthobrachia they resemble the spreading, lobular, but still unbranched processes of some of the Rhizopods, such as Difflugia; while in Cydippe the palpocil assumes a perfect pseudopodal type, being capable of complete retraction and rhizopodal extension.

In noticing similarities of structure between the protozoa and animals of higher type, it will be proper to mention the planula of Coryne glandulosa (Dalzell), which Mr Gosse and myself afterwards have observed to have a true amæboid type. It has neither cilia nor palpocils, but moves along the vessel in which it is contained by throwing out obtuse lobes, or rather enlargements of the advancing portion.

4. *Atractylis bitentaculata* (nov. sp.) T. S. W.

Polypary creeping, retiform. Polyps club-shaped, nearly sessile, non-retractile, minute, each furnished with two erect tentacles.

Found in a Pecten shell dredged from the Firth of Forth, near Inchkeith. The polyps of this zoophyte are very minute, and thickly clustered on a retiform polypary. They have the habit, like that of Lar (Gosse), of quickly and repeatedly bending down the body until the mouth is brought close to the surface on which the zoophyte grows.

5. *Atractylis quadri-tentactulata* (nov. sp.) T. S. W. (Fig. 5.)

Polypary creeping. Polyps sessile, columnar, non-retractile, short. Tentacles, alternate, four; two long and depressed, two very short, and nearly at right angles to the body of the polyp.

This zoophyte was found creeping along the side of a large vessel of sea-water containing shells and zoophytes, dredged from the Firth of Forth. The two long tentacles were depressed, so as to touch the glass to which the zoophyte adhered. The shorter tentacles were occasionally absent. The bodies of the polyps were enveloped in a ball of extraneous matter,

adhering to a glutinous coat (*colletoderm*), with which they and the horny polypary (scleroderm) were covered, and which could only be removed by directing a strong stream of water against it.

6. *Coryne ferox* (nov. sp.) T. S. W. (Fig. 6.)

Polypary creeping. Polyp-stalks single, smooth. Tentacles, thick, short, having the capitate cluster of thread-cells scarcely larger than the width of the tentacle. Medusoids, developed from the body of the polyp beneath the tentacles, and similar to those of *C. decipiens*.

This Coryne resembles C. decipiens (Dujardin) in the shape and mode of development of the medusoid, but it differs from that zoophyte in its more robust and clumsy habit. The tentacles of C. decipiens are long, tapering, and capped with large bulbs of thread-cells. Those of C. ferox are short, nearly of equal thickness throughout, and though they are surmounted by a cluster of thread-cells, the thread-cells are so few in number that the tentacles can scarcely be termed capitate. A delicate epidermis of colletoderm passes over the whole body and tentacles of the polyp, which cause them to assume a dirty appearance, as it often serves to support a downy growth of very minute algæ. C. decipiens is the hardiest of all the hydroidæ: I have often known a colony of it to live for several years in captivity, whereas *C. ferox* seldom survives more than a few days after having been removed from the sea. It inhabits, generally, crannies in large shells tenanted by hermit-crabs, and rarely, the hollows of stones found in pools at extreme low-water mark.

7. *On Boderia Turneri* (nov. gen. et sp. T. S. W.) *and its reproduction.*

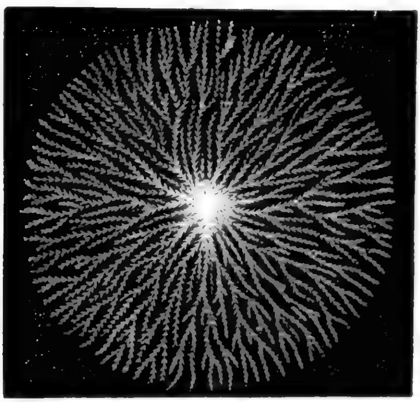
In July 1863 a number of shells and zoophytes were brought in by my son, Mr Strethill Harry Wright, which he had dredged in the neighbourhood of Inchkeith. They were placed in vessels of sea-water, and in a few days a number of Rhizopods appeared crawling up the sides of the glass, amongst which were specimens of that to which I have given the name of Boderia. The animal (Pl. xv, fig. 1) consists of a simple mass of brown or orange sarcode, enclosed in a very delicate and colourless membranous envelope, from openings in which it protrudes long pseudopodial branches, generally three or four in number, but sometimes more numerous, especially in the larger specimens. The animal's shape is variable, sometimes presenting the appearance of a conical mass, at other times that of an extended plate with many angles, from each of which protrudes a branch or bundle of pseudopodia. In the majority of individuals a single large transparent nucleus appears, but in others three or four such bodies appear grouped together; while in others, again, as many as nine or ten have been detected grouped in two clusters (fig. 2). In this case, however, I am disposed to think that the individual was composed of two animals in a state of conjugation, as it was always elongated and slightly contracted between the masses of nuclei. These animals, from their large size (from one-sixteenth to one-quarter of an inch in length), could be readily transferred to a large flat cell under the microscope, when the excessively rapid movement of the sarcode afforded a very interesting and astonishing spectacle. Each of the great pseudopodia consisted of a number of streams, some rapidly coursing outwards, others passing inwards more slowly, and dragging home masses of diatoms, minute algæ, and infusoria. Even in the most minute branches of the periphery a double movement in opposite directions was clearly visible under high amplification. In fact the whole organism reminded one of a great central railway station, the meeting-point of numerous converging lines, to which an unceasing flow of traffic was ever tending. A rude touch, as with a needle-point, to the animal itself,

had the effect of arresting the outward movements, and of determining the whole currents rapidly to the centre.

An explanation of the movements of the pseudopodia is extremely difficult; and, indeed, the same may be said of the nature of pseudopodia and whole structure of the rhizopod itself. We find it difficult to believe that a mere mass of slime, apparently homogeneous, can determine such purpose-like and varied movements through the widespread and ever-varying extension of its network, and can instantly correct or alter the course of these movements at will or from the effect of external stimulus. Accordingly, Reichart has dissented from the sarcode theory, first promulgated by Dujardin and strongly insisted on by Schultz, and is of opinion that the pseudopodia consist of bundles of excessively fine filaments; so fine that a perceptible thickening scarcely appears when several filaments come together, or when the magnifying power is raised from 450 to 700 diameters. He states "that when the animal first extends its pseudopodia the more simple radiate arrangement predominates; soon afterwards the apparent ramifications commence, and become constantly more numerous. The branches, after issuing or becoming free, easily reach their neighbouring filaments, apply themselves to these, and then appear like anastomoses. By multiplications of such apparent anastomoses these reticulated figures are produced, which are known under the name of the sarcode net. At the same time bridge-like unions and membrane-like structures between the filaments become visible." "Favourable conditions for the multiplicity of forms, and for their ready and often imperceptible change, are also furnished by the number of filaments and their flexibility." And he further states that "the appearance produced by these readily moveable parts in the protean system of filaments, as if a moveable substance assumed any form or spread and formed itself into any shape, is an illusion which is set up especially by the circumstance that individual minute parts, which are readily displaceable throughout, can never be distinguished at their point of contact. No doubt the theory of Reichart is exceedingly ingenious and plausible, but it appears to me to be especially open to two objections. 1st. If the infinitely fine fibres of Reichart have such an amount of cohesion as to enable them to form bundles and membranes of apparently homogeneous structure, such an amount of cohesion would prevent the rapid motion of the fibres on each other in opposite directions. 2ndly. We see the same filamentous arrangement of protoplasm in the interior of the vegetable and animal cell. In the cell of Anacharis, for instance, when the circulation has been arrested, we frequently observe the protoplasm distributed as a network of threads over the whole cell. After a time of rest, movements commence in the threads in no respect differing from those of the pseudopodia of rhizopods, and the protoplasm creeps to the borders of the cell where the cyclosis commences; so in the large cells of the tentacles in Coryne the sarcode or protoplasm assumes a similar thread-like and reticulated arrangement, and the reticulations are seen to undergo slow change of shape, though it is difficult to detect the actual moving of the sarcode. Each of these cells contains an imprisoned rhizopod. In a paper on the Equorial Pipefish, read to the Royal Physical Society, I showed that a true rhizopodia structure existed in the pigment corpuscle of the fish, which consists of a moving nucleated mass of protoplasm, branching and coalescing like the pseudopodia of the animal now under consideration. Now we cannot suppose that the protoplasm of Anacharis, of Coryne, or of the pigment corpuscle, is formed of fine cohering fibres.

It is true that we are at a loss to understand the phenomena of the movement in sarcode; indeed, we can scarcely form any conception of a power capable of producing such movements, or of its mode of action. But we are equally at fault with regard to the movements of muscular fibre, or

those of cilia. It is probable that in all these cases the movements are due to modifications of the molecular attraction of the tissue, caused by a corresponding modification of the vital force, analogous to the modification in the cohesion and molecular forces effected in inorganic matter by alterations of electric polarity. Thus, if a large globule of mercury be rendered positive by contact with the anode of a voltaic arrangement in a solution of hydrochloric acid, its coerced affinity for the solution will overcome the attraction of cohesion between its own atoms, and it may be drawn out in threads, which will remain permanent while the mercury is in connection with the battery; the moment, however, the mercury is released from its forced state of polarity towards the solution, by removing the battery or touching the metal with the cathode, all the threads of the metal are drawn in with convulsive violence, and it assumes its natural cohesive or globular state, being repelled by the solution which before attracted it. By varying the solutions and employing large masses of metal, I have been able to produce long-continued and life-like movements in mercury and other fluids, solely due to minute changes in cohesive attraction between the elements employed, which I have fully described in a paper in the *London Ed. and Dublin Phil. Mag.* for Feb. 1860. Another very beautiful instance of movements produced by the modification of cohesive attraction is shewn in the production of electric cohesion figures, which I have lately discovered. A sheet of chemically clean plate-glass is laid upon a piece of black paper moistened with a saline solution so as to form a black mirror; a single drop of sulphuric acid is placed in the centre of the mirror and the drop of acid and the paper are connected with the opposite poles of an induction coil; as long as the machine is inactive the drop remains globular and quiet, but the moment the electric current is set in motion, the drop begins to put forth *pseudopodia*, as it were, and spreads itself over the glass in a beautifully branched figure resembling the pigment corpuscles of the fish. Fluids of other chemical constitution give varying and characteristic dendritic forms; the wood-cut shews the electric figure of cyanide of potassium on a fresh-split surface of mica used instead of the plate-glass.



In citing these instances, I do not mean to infer that electricity is engaged in the movements of the sarcode or other living tissues, but merely to shew how movements resembling them can be closely imitated by processes connected with inorganic matters, the rationale of which we have no difficulty in understanding.

Reproduction of Boderia.—In a former paper read before the Royal Physical Society, I communicated the discovery of large ova, with germi-

nal vesicle and spore, in a rhizopod Truncatulina and considered that, as it was impossible that bodies of so great a size could escape from the excessively minute foramina of the shell in that animal, it was probable that in these genera a "polymorphic development" took place similar to that described by Carter in *Amœba verrucosa*, and such also as seems to occur in Gregarina, either with or without previous conjugation. In Boderia such a mode of development plainly occurs. In specimens under constant observation the large transparent nuclei or ova were seen to disappear, and some hours afterwards the sarcode of the animal burst through its envelope and spread itself in ragged masses, connected by thick processes (fig. 3), over the glass. In the course of a few hours later the sarcode became entirely dissipated, leaving a swarm of naviculoid bodies attached to the glass (Fig. 4), from each of which, in a day or two, there issued a minute nucleated amæboid mass (fig. 7). These little amæbas existed for weeks as a closely aggregated band (the produce of numerous parents) near the surface of the water, without assuming an envelope, or putting forth pseudopodia. The actual change from the amæba to the rhizopod form was not observed, but minute specimens of Boderia gradually made their appearance in considerable numbers at the lower part of the vessel.

I am disposed to think the change from the naked amæba to the encysted rhizopodic form in this animal constitutes a distinct stage in its development.

We have thus the life-histories of the Rhizopoda and Gregarinidæ brought in very close analogy to each other: in Gregarina we have a conjugating process, followed by an encysting of the animals; or encysting may take place in a single Gregarina; next globular vesicles appear in the cyst, and these become metamorphosed into "pseudo-naviculæ." The cyst of the single or conjugated Gregarina bursts, and the pseudo-naviculæ escaping, presently give vent to amæboid bodies, which at length become developed into Gregarinæ.

The consideration yet remains—must the so-called nucleus be considered as an ovary or true ovum? I am disposed to view it as the latter on account of the existence of the single germinal vesicle and spot within it, as observed in Truncatulina, and I consider the so-called polymorphic development as comparable to the fissure stage in the ova of higher animals, but which, in the case of the unicellular Gregarina and Rhizopod, becomes a final stage of egg-development; and I would hint, that in the higher animals the fissured elements of the ovum remain together to form a multicellular animal, while in these lower ones the same elements finally separate at a corresponding stage to form a swarm of unicellular animals.

DESCRIPTION OF PLATE XIV.

1. Section from umbrella of *Stomobrachium octocostatum*, a, a, a, supplementary canal system.
2. *Acanthobrachia inconspicua.*
3. Rudimentary tentacle of do.
4. Tip of one of long tentacles shewing the long palpocils.
5. *Atractylis bitentaculata.*
6. *Atractylis quadritentaculata.*

DESCRIPTION OF PLATE XV.

1. *Boderia Turneri.*
2. Do. conjugated (?) with two clusters of ova.
3. Do. breaking up and spreading its sarcode over the glass of the tank.
4. Do. Sarcode dissipated and naviculoid bodies adherent to the glass.
5. Naviculoid body enlarged and containing amæba.
6. Empty envelope of naviculoid body.
7. Amæba free and attached to glass.

ON POISONING BY CARBONIC OXIDE GAS, AND BY CHARCOAL FUMES. By Arthur Gamgee, M.D. F.R.S.E. F.C.S., *Assistant to the Professor of Medical Jurisprudence in the University of Edinburgh.*

Although the fumes of charcoal have, probably from the earliest times when this form of carbon was used as fuel, been acknowledged to possess specific and very remarkable toxic properties, it has only very recently been shewn that carbonic oxide plays an important part in their production[1]. Our knowledge of the action of carbonic oxide and of charcoal fumes is of very recent date. It is true that, as far back as the commencement of the present century, Nysten investigated the action of carbonic oxide gas upon animals, but this author finding that when small quantities of carbonic oxide were injected into the circulation no evil effects followed, and that death only occurred when the quantity of gas introduced was so large as to be capable of producing death in the same mechanical manner as air does under the same circumstances, was led to the exceedingly erroneous conclusion that carbonic oxide is destitute of active noxious properties. Nysten, moreover, stated that carbonic oxide caused the blood to assume a brownish tint, whereas it is a most characteristic property of this gas to render the blood intensely and permanently florid[2]. Leblanc[3], carrying further the investigation of the composition of the fumes of burning charcoal which had been commenced by Orfila[4], proved that these contained small quantities of carbonic oxide gas, and that this is so poisonous that birds are rapidly killed when placed in an atmosphere containing only one per cent. With the exception of many cases being recorded from time to time which proved how poisonous are the fumes of charcoal, and how formidable are the symptoms which may follow the inhalation of carbonic oxide gas, no connected or correct knowledge of the mechanism of poisoning by carbonic oxide or by charcoal fumes was obtained until the publication of Prof. Claude Bernard's mémoirs on this subject. In these mémoirs the French experimenter shewed for the first time that blood which has been exposed to the action of carbonic oxide gas, as well as the blood of animals poisoned by it, presents in the veins, as well as in the arteries, an uniformly florid arterial colour, which however does not disappear and give place to a venous hue as is the case with normal arterial blood. Bernard also found that the blood which had been exposed to carbonic oxide had lost, to a great extent, its property of absorbing oxygen from the air. Thus blood which, before being acted upon by carbonic oxide, absorbed 8·2 per cent. of oxygen when placed in contact with air, was only capable of absorbing 1·66 per cent. after the action of carbonic oxide[5], a change which was attributed by Bernard to some influence of the poisonous gas on the blood corpuscles. "When," says Bernard, "blood is placed in contact with a gas, as carbonic acid, oxygen, or even nitrogen, an interchange between these gases and those of the blood takes place; it is, indeed, by such a process that the displacement of the gases of the blood may be effected. Carbonic oxide disturbs or prevents this interchange; under its influence the corpuscles being physiologically altered lose the power of seizing the gases in the space surrounding them, or of ceding the gases which they them-

[1] In his remarkable work, *De mortis Artificum Diatriba*, Ramazzini, then Professor of Medicine at Padua, refers in very clear terms to the evil effects caused by the fumes of burning charcoal, and makes an observation which is extremely remarkable: "Ad carbonum malignitatem emendendam lubet remedium proponere quod in usu est apud omnes fere artifices, ubi per hyemem carbonibus accensis in suis officinis uti necesse sit, frustum enim ferri inter carbones reponunt, sic enim carbonum virulentiam corrigi existimant, forsan dici posset spiritus illos malignos carbonis in ferream substantiam vim suam exercere, *sive ferrum ipsum eosdem absorbere.* (Ramazzini, *Opera omnia.* Genevæ, 1717, p. 664). Although it is very doubtful whether the plan mentioned by Ramazzini would prove useful, it is not a little remarkable that carbonic oxide is perhaps chief amongst the noxious principles of charcoal fumes, and that the very recent researches of Graham have revealed the very startling fact that when iron is raised to a red heat it absorbs many times its volume of carbonic oxide, and that after cooling it actually retains 4·15 volumes of the gas. "On the Absorption and Dialytic Separation of Gases, by Colloid Septa," by Thomas Graham, F.R.S., *Phil. Transactions*, 1866, p. 438.

[2] Nysten, *Recherches de physiologie et de chimie pathologique.* Paris, 1811.

[3] Leblanc, *Ann. D'Hyg.* 1843, Vol. II.

[4] Orfila, *Toxic. Générale*, Vol. II. p. 474.

[5] Bernard, *Leçons sur les subst. tox. et Médicamenteuses*, p. 173.

selves contain." Although a great step had been made towards a correct knowledge of the action of carbonic oxide, inasmuch as it had been determined that the specific action of carbonic oxide consisted in destroying the capability of the blood to absorb oxygen, no correct idea was entertained by Bernard as to the mechanism by which this is effected. "Carbonic oxide," says Claude Bernard, "acts by preventing arterial blood becoming venous. *It does not prevent the arterialization of the blood in its passage through the lung:* it does not therefore cause asphyxia, i. e. *it does not, at first* (il n'empêche pas d'abord) *prevent the absorption of oxygen.*"

Shortly after Professor Claude Bernard had published his researches on carbonic oxide, Lothar Meyer, working under the direction of Bunsen, amongst his other well-known investigations on the gases of the blood, studied the action of carbonic oxide, and whilst he confirmed the statement of the French physiologist as to the expulsion of oxygen by carbonic oxide, he was led to the conclusion that for every volume of carbonic oxide absorbed by blood there is one volume of oxygen expelled, and was led to the induction which has since been shewn to be correct, viz. that the blood contains a substance which has the power of forming a definite chemical compound either with oxygen or with carbonic oxide, a molecule of the one gas being able to replace a molecule of the other[1].

After the researches of Bernard and Meyer little was added of interest to our knowledge of the mechanism of carbonic oxide poisoning until a new method of investigation was brought to bear upon the subject. It is true that Dr Hoppe had shewn[2] that the blood of animals poisoned by carbonic oxide, besides being possessed of a remarkably florid colour when mixed with its own volume, or twice its own volume, of strong caustic soda (of sp. gr. 1·3) and well shaken, gave a coagulum of red colour, which when drawn over porcelain left streaks of a cinnabar-red colour; whilst normal blood treated in the same way yields a black mucilaginous mass; and that this observation was actually of service in investigations of a judicial nature[3]; still such an observation, whilst it gave support to the hypothesis of Meyer that under the influence of carbonic oxide a new substance was formed, threw very little light on the subject.

The discovery by Hoppe of the peculiar and beautiful absorption bands observed in the spectrum when light is passed through blood before being examined by a prism, and the still more remarkable discovery by Professor Stokes of the fact that the blood-colouring matter is capable of existing in two conditions, in one of which it is more highly oxidized than the other, that the less oxidized substance may readily be produced by acting upon blood by suitable reducing solutions, that it is characterized by a single and very characteristic absorption band, and that by mere agitation with air it again becomes converted into the more highly oxidized substance—these facts opened a new field for the investigation of such poisonous substances as appeared to exert a special action on the blood. If, as Professor Stokes supposed, cruorine (a term which is synonymous with hæmoglobin, the name now universally used in Germany to designate blood-colouring matter) be really the agent by which oxygen is for a time fixed in the blood afterwards to be used in oxidation processes going on in the system, it would be conjectured that a condition of the blood in which, as in carbonic oxide poisoning, the most characteristic property of blood—that of fixing oxygen—had been almost completely destroyed, would be marked by a remarkable change in the properties of cruorine; if the hypothesis of Professor Stokes were correct, it was more than likely that the colouring matter would be found incapable of reduction, or when reduced incapable of fresh oxidation. Such was the reasoning which led me at a time (early in 1866) when I was quite ignorant of researches to which I shall immediately draw attention, to examine whether blood which has been treated with carbonic oxide gas, acts similarly to normal blood when treated with reducing solutions—an examination which led me, independently, to observe a fact which had been some time before noticed by Hoppe-Seyler and published by him[4], viz. that blood which has been treated with carbonic oxide, besides acquiring a permanently florid character, remains quite unaffected by such reducing agents as were shewn by Stokes readily to deoxidize blood-colouring matter, i. e. the two bands of scarlet cruorine remain unchanged, and are not replaced by the wide absorption band of reduced or purple cruorine. The observation of this remarkable fact led me to continue my experiments, and

[1] Henle's *Zeitschrift f. rat. Med.* Bd. IV. 1858. S. 88.
[2] Virchow's *Archiv.* Bd. II. 3 Heft, 1857. S. 288.
[3] Casper's *Handbook of For. Med.* New. Syd. Soc. Vol. II. p. 131.
[4] *Zeitschrift für Anal. Chemie*, Vol. III. p. 439.

whilst I now intend to discuss these, very specially with regard to their bearing on the functions of blood-colouring matter, and in their application to medical jurisprudence, I shall mention what has been added to our knowledge of the particular points discussed through the labours of the numerous scientific men who have in Germany investigated this subject.

When blood is placed in contact with carbonic oxide, as by causing a stream of the gas to pass through blood, or by causing a living animal to inhale it for some time, a portion of the oxygen of the colouring matter is expelled and replaced by carbonic oxide; a definite compound is thus formed whose physical characters are identical, or nearly so, with those of normal blood-colouring matter, but which differs from the latter in being incapable of yielding a less oxygenized substance when treated with reducing agents.

On allowing pure carbonic oxide gas, or carbonic oxide contaminated with even large quantities of carbonic acid to bubble through blood, the characteristic florid colour observed by Bernard is almost immediately produced, at the same time that oxygen is evolved. The reaction is best observed when the blood is brought in contact with carbonic oxide in a tube over mercury and then agitated. We are at once led to inquire whether this change of colour is due to the formation of the peculiar compound whose properties are to be described, and the answer appears to me to be decidedly in the negative, for I have always found that when blood is considerably diluted and then treated with carbonic oxide it fails to acquire the characteristic colour, and similarly that the florid colour of blood saturated with carbonic oxide is destroyed by dilution. Moreover, when pure crystallized blood-colouring matter (hæmoglobin) is dissolved in water, and the solution is saturated with carbonic oxide, whilst the CO-compound is formed, the colour is only slightly heightened, and differs *in toto* from the colour of carbonic oxide blood. These facts lead me to think that it is in great measure to an action on the physical characters of the blood-cells that the peculiar colouration produced by carbonic oxide in blood is due. That carbonic oxide has a decided action on the constituents of the corpuscles, other than their colouring matter, is rendered highly probable by the observation made by Bernard that the corpuscles of blood saturated with carbonic oxide retain their shape for a remarkable length of time.

The completeness with which the blood has been acted upon by carbonic oxide may be judged of to a great extent, though not entirely, by the greater or less intensity of the florid colour, for although as soon as this colour is produced the blood is found to have changed in its deportment to reducing agents, yet the florid colour may be marked before the change has been completely effected. Whilst on microscopic examination the blood corpuscles are seen unchanged, on examining the blood diluted with water by means of a spectroscope, no difference is at first to be perceived in the spectrum; the beautifully defined dark band immediately below D is seen in all its distinctness, separated by a green interspace from the broader and less sharply defined absorption band which extends to Frauenhofer's line E, whilst the greater part of the more refrangible rays of the spectrum are cut off. On adding to the blood, suitably diluted with water, a solution of sulphide of ammonium, or such solutions of protosalts of iron and tin, as were used by Professor Stokes, no change is observed to take place in the appearance or position of the bands. Professor Hoppe-Seyler, who first observed the non-reduction of CO-blood, used sulphide of ammonium. I, however, especially for medico-legal purposes, prefer using a pretty strong ammoniacal solution containing protochloride of tin, and an alkaline tartrate. On mixing the blood with such a solution, and then heating it very gently, instead of the colour changing to a dark venous hue, as is the case with normal blood, it remains quite florid, and if the blood solution experimented upon be very strong, it becomes, after the action of the tin has gone on for some time, turbid, and deposits a carmine red amorphous precipitate, which is of itself quite characteristic of CO-blood. However long the process be carried on, the two beautiful absorption bands of scarlet cruorine remain perfectly distinct; indeed, if the blood has been fully acted upon, they are absolutely unaltered. It is almost needless to add that in the case of normal blood the two absorption bands of scarlet cruorine disappear when the tin solution has acted for a short time, and are replaced by the absorption band first described by Professor Stokes, which occupies very nearly the position of the green interspace between the two original dark lines. In the case of normal blood this absorption band has edges which are less defined than those of the original blood bands. When the saturation with carbonic oxide has been imperfect, the blood bands will, when treated with a reducing solution, be more or less affected, and may become very indistinct; the green space may become shaded over, and on superficial examination it would appear that a spectrum of reduced

cruorine had been obtained, whilst a more minute examination would shew that the centre of the absorption bands is less obscure than its margins, an appearance which is never seen in the spectrum of reduced cruorine from normal blood. This is an observation which I have often made with an ordinary spectroscope and with Mr Sorby's micro-spectroscope.

When blood saturated with carbonic oxide is placed, for a considerable time, in the vacuum of a good air-pump, and the exhaustion is pushed until the tension of the air in the receiver does not exceed three or four millimetres, no change is produced in the properties of the blood. After the exposure in vacuo the blood is still irreducible.

When such blood is evaporated to dryness in the water-bath at a heat not exceeding 140° Fah., the dry residue when treated with water yields a solution of colouring matter which is as irreducible as the original blood.

It is well known that blood-colouring matter can readily be obtained in a crystalline condition from the blood of the dog, cat, guinea-pig, &c. The blood of the dog is, with this object, to be allowed to coagulate and placed aside until the serum separates; the clot is then squeezed and the expressed fluid is diluted with one and a half times its bulk of water, and set aside for some time. It is then treated with one-fourth of its volume of rectified spirit. Usually there is, in a few minutes, an abundant precipitation of crystals of blood-colouring matter, and after some hours, more especially if the temperature be low, the fluid has acquired a semi-solid consistence and has become a magma of crystals. Hoppe has shewn that by passing a stream of carbonic oxide gas through the mixture of blood and water, before adding the alcohol, crystals are precipitated which are identical in physical characters with those of normal blood, but which have the property which characterizes CO-blood of being unacted upon by reducing agents.

When a solution of blood is mixed with a very large excess of a reducing solution, and carbonic oxide is then passed into the solution, at once the single band of reduced cruorine disappears and gives place to the two well marked absorption bands characteristic of scarlet cruorine and CO-cruorine.

Several observers have made the attempt to determine the amount of oxygen which the crystallized blood-colouring matter is capable of absorbing, and an attempt has likewise been made to determine the amount of oxygen which carbonic oxide is capable of expelling from the blood-colouring matter. As yet, however, the results are not sufficiently concordant to allow us to attach much weight to them.

Whilst Hoppe[1] found that 100 grammes of dry powdered crystals of hæmoglobin absorbed 41·1 cub. cent. of oxygen (at 0° Cent. and 760 M. M.), Preyer[2] found that 100 grammes of hæmoglobin absorbed 130 cubic centimetres of oxygen (at 0° Cent. and 1 metre B. P.).

On the other hand Dybkowsky[3], who first saturated solutions of hæmoglobin with oxygen and then brought them in contact with carbonic oxide, found that the amount of oxygen yielded by 1·49 grammes of the substance dissolved in 68·85 cub. centimetres of water, amounted to 1·76 cub. centimetres, so that 100 grammes of the substance would yield 118·12 cub. centimetres of oxygen.

Such extremely discordant results prevent our attaching much importance to the statements with regard to the amount of oxygen in hæmoglobin which is in a loosely combined condition. It is probable that further experiments with pure blood-colouring matter will fully prove the truth of Meyer's hypothesis, and shew that the carbonic oxide compound differs from normal blood-colouring matter, in the replacement of a portion of the latter by an exactly equal volume of carbonic oxide; but as yet this very remarkable quantitative relation has certainly not been established.

When blood which has been treated with carbonic oxide is acted upon by acetic acid, it appears to undergo the same change as normal blood, and amongst the products of decomposition is found hæmatine, whose presence is at once recognized by its peculiar and characteristic spectrum I thought it would be interesting to ascertain whether the carbonic oxide which had been absorbed by blood would on the addition of acids be given off unchanged, and for the determination of this point I made use of the arrangement recommended by Bunsen for the determination of the gases of water. The flask was in this case filled with a solution obtained by digesting dried CO-blood, for some time, in tepid

[1] See *Lehrbuch der Phys. Chemie*, von Dr Kühne, 2to Lief. p. 218. 1866.

[2] Kühne, *op. cit.* p. 218.

[3] Hoppe-Seyler, *Med. Chem. Untersuchung.* I. 117—132. *Centralblatt*, 30 June, 1860. No. 29.

water; and besides the solution, the flask contained small glass bulbs partially filled with glacial acetic acid and sealed. The operation was conducted exactly as in the case of determining the gases in water; after the whole of the air had been expelled from the tubes destined to receive the evolved gases, and a vacuum had been obtained, the communication between the blood flask and the tubes was opened, and the former, having been shaken so as to break the acid bulbs, a very gentle heat was applied. The gases collected in the vacuous tubes were found on transference to the mercurial trough to contain a considerable quantity of carbonic oxide; for after absorbing the carbonic acid by caustic potash, and the oxygen by a phosphorus ball, very considerable contraction occurred on the addition of a solution of subchloride of copper. In a similar manner I filled the flask with a solution of blood-colouring matter, and conducted the process as above, but without using acid, and I raised the temperature to about 180° Fah. Again in this way I obtained considerable quantities of carbonic oxide.

Having now discussed the changes which take place in the blood under the influence of carbonic oxide, the questions suggest themselves; 1st, As to whether these changes supply us with a means sufficiently accurate and delicate to warrant our employing it in medico-legal investigations; and 2ndly, Whether the same changes occur when charcoal fumes are the cause of death. In the case of poisoning by pure carbonic oxide gas, I have, in a course of very many experiments on rabbits, dogs, frogs, and mice, found that *invariably* the remarkable colouration was induced in the blood, and not only was it observed in the blood, but likewise in specially vascular organs. The remarkable carmine-red injection of the liver in carbonic oxide poisoning is indeed a most striking appearance, and is quite characteristic. The kidneys, too, are usually of an exceedingly florid colour, and the muscles have a beautiful pink colouration, which, if once seen, can never be forgotten. It may incidentally be mentioned that if a portion of muscle be suspended in an atmosphere of carbonic oxide gas, it very readily acquires a most splendid colouration; if placed in a jar which has been very perfectly exhausted and into which carbonic oxide is subsequently admitted, the occurrence of the decomposition of muscle and the other animal tissues is, to a very great extent, postponed and modified.

In all cases of carbonic oxide poisoning I have found the blood either wholly or partially irreducible; even where it was only partially so, the reactions with reducing solutions were sufficiently characteristic to enable a certain opinion as to the cause of death being given. The more unsatisfactory cases were assuredly those in which death was induced almost instantaneously, as by plunging rabbits into jars filled with pure carbonic oxide gas, for in these a few hurried gasps and a short attack of convulsions occurred, and in a few seconds death took place. In those cases, on the other hand, in which the animal was exposed to the action of the diluted gas, and where life was protracted for some minutes, the most satisfactory results were obtained with the spectroscope. In the cases which I allude to as unsatisfactory, the carbonic oxide colour of the blood and tissues is well marked if the animal be examined shortly after death, but as the saturation has been imperfect, the indications obtained by the spectroscope become exceedingly indistinct after 48 or 56 hours.

A correct solution to the second part of the question, viz. *As to whether in poisoning by charcoal fumes the changes occur which are characteristic of carbonic oxide, and whether the spectroscope affords us in this case valuable aid*, is of the highest importance in a medico-legal point of view. Assuredly the cases of poisoning by pure carbonic oxide will be extremely rare; whilst experience teaches us that cases where death has been caused by the fumes of charcoal, coke or coal, do from time to time occur, and the means of affirming with certainty that a sample of blood has unmistakeably been exposed to the action of one of the products of combustion, will often put a stop to a long, laborious, and useless investigation.

Charcoal fumes vary so greatly in their chemical composition, according to the greater or less amount of air supplied to the burning fuel, that we should be led to suppose that considerable variation would be found in the symptoms and changes induced by them—a supposition which is fully borne out by facts in our possession and by the experience of many observers.

In my own experiments I have, whenever I have killed animals by the fumes of charcoal, always succeeded in producing the remarkable colouration of the tissues and blood; that this is not invariably the case is abundantly proved by the very numerous cases of poisoning by charcoal fumes which are to be found recorded in our medical periodicals, as well as in our treatises on toxicology and medical jurisprudence, in many of which a dark colour of the blood has been noticed. In my experiments I placed the animals on which I experimented in a

small iron drying chamber which had a capacity of about 1600 cubic inches, and in the chamber a small chauffer containing burning charcoal was placed. The combustion of the charcoal, in consequence of the small supply of air, took place slowly and imperfectly, and this may have influenced to no small extent the results which I obtained.

Whilst in all the cases in which I induced death by charcoal fumes, the peculiar colouration of the blood was noticed, in some it disappeared after exposure to air for a short time. This disappearance shews that only a partial action on the colouring matter has taken place, that there is a considerable quantity of normal cruorine present, and that the destruction of the carbonic oxide compound, under the influence of oxidation processes, has gone on to a sufficient extent to affect the characteristic colour of the blood.

That, at any rate, in a large number of cases of poisoning by charcoal fumes the carbonic oxide which they contain does induce its action on the blood and thus aids to destroy life, is an undoubted fact. That, however, in others carbonic acid is the agent which really kills, whilst in all it aids the occurrence of fatal symptoms, is proved by incontrovertible facts. Claude Bernard believed that when carbonic acid is inhaled it causes death in a purely physical manner, by putting a stop to the gaseous interchanges which are constantly going on between the inspired air and the blood-gases. In order that this interchange should go on, as it normally does, it is necessary, according to the French physiologist, that there should exist as marked a difference as actually exists between the blood-gases and the atmosphere.

In the following sentence is to be found a résumé of Bernard's views on the mechanism of poisoning by carbonic acid:—

"Lorsqu'il est dans le sang, l'acide carbonique n'empêche pas ce liquide de se charger d'oxygène, parceque la respiration est un échange et que, pour que cet échange se fasse, il faut que les gaz soient de nature différente. Quand au lieu d'arriver dans le poumon avec le sang l'acide carbonique est dans l'air, deux gaz de même nature ou s'en rapprochant sont allors en présence, et l'échange est incomplet, on même peut n'avoir plus du tout lieu. C'est alors que l'acide carbonique du sang, ne pouvant plus en sortir par échange, s'accumule dans ce liquide. On peut expliquer d'une façon analogue comment bien que l'azote soit insoluble, le mélange de l'azote et de l'oxygène dans l'atmosphere empêche ce dernier gaz de se dissoudre en aussi grande proportion dans le sang ou il-ya de l'azote[1]."

That carbonic acid acts injuriously in the way pointed out by Bernard is exceedingly likely, although its poisonous action must be also due to its power of displacing a portion of the oxygen from the blood-colouring matter. When a stream of carbonic acid is passed through blood for many hours, the absorption bands of scarlet cruorine become fainter and fainter, and ultimately the blood is found to be reduced and to furnish the spectrum of reduced or purple cruorine. This reducing action, which to be complete requires the passage of the gas through blood for many hours, probably occurs much more rapidly in the system of animals inhaling carbonic acid, and even if taking place partially would, of necessity, be productive of most serious consequences.

As the action of charcoal fumes must be due to the colouring matter being, under the influence of the carbonic oxide, changed in constitution, and rendered unfit for respiratory changes, or to the colouring matter being deprived of oxygen by the carbonic acid, whilst the interchange of gases is arrested by it, and as the two latter causes are quite sufficient to cause death, and may exist where the first does not, it is obvious that in some cases of poisoning by charcoal fumes, the blood will be found of a dark venous, and not of a florid, colour, and unchanged in its reaction with reducing solutions. The mere fact of the blood being dark does, however, not prove that such blood is reducible. I have often found that when blood which has only been partially saturated with carbonic oxide has after a lengthened exposure to the air lost its florid colour and become apparently venous, when treated with reducing solutions it is not completely reduced. Now an incomplete reduction is, for medico-legal purposes, as important as the complete absence of reduction, and can with perfect safety be relied upon. Although we cannot positively affirm from the absence of certain changes in the blood, that death has not been due to charcoal fumes, in a large majority of cases such positive evidence will exist as will justify a very decided opinion being pronounced. There appears to be one other gas besides oxygen and carbonic oxide, which has the power of forming with the blood-colouring matter a compound characterized by two dark bands undistinguishable from those of normal blood; this gas is nitric

[1] *Op. cit.* p. 207.

oxide. Dr Hermann has found that when blood which has been rendered ammoniacal is treated for a long time with a stream of nitric oxide, it becomes irreducible, and he affirms that this compound, which crystallizes like normal blood-colouring matter, differs from it in its loose oxygen being replaced by an equal volume of nitric oxide. I have myself confirmed the observation of Hermann as to the formation of this substance under the influence of nitric oxide. That its formation does not in any way interfere with the value of the non-reduction test as a means of distinguishing the blood of those who have perished from the effects of the fumes of charcoal, is obvious, for the following reasons:—

1st. Nitric oxide gas if inhaled would not give rise to the compound described by Hermann. When coming in contact with pure blood, nitric oxide causes the blood to assume a dirty brownish colour and produces a change in the spectrum, which is also observed when blood is treated with alkaline nitrites, with nitrite of amyl and ethyl, and with nascent nitrous acid, viz. the two absorption bands of scarlet cruorine are rendered faint, and an additional band in the red, coincident with the hæmatine band, is seen. That this is not due to a partial conversion into hæmatine is however obvious, when the action of ammonia and of reducing solutions upon such blood is examined [1].

2ndly. Even when blood is mixed with ammonia and nitric oxide gas is passed through it, the action takes place slowly.

I have myself examined the action of a large number of substances on blood, and can, with the exception of nitric oxide, confirm the statement of Hoppe, that no substance but carbonic oxide can render the blood irreducible.

Besides carbonic oxide there are two substances which have to a remarkable extent the property of causing the blood to become florid, and when rendered florid of retaining this colour for some time, viz. nitrous oxide and prussic acid. Neither of these substances has, however, the power of rendering the blood irreducible; on the contrary, it is stated by Kühne that when nitrous oxide is passed through blood it acts like carbonic acid and hydrogen, and, expelling oxygen, actually reduces the colouring matter.

The last question to be considered relates to the explanation of the absence of evil effects when a little carbonic oxide is introduced into the circulation—a fact which had been noticed by Nysten, and which led him erroneously to the conclusion that carbonic oxide was destitute of active poisonous properties—and likewise to the explanation of the fact, that the blood of animals which have been nearly killed by the inhalation of carbonic oxide gas readily re-acquires its normal properties and appearance, if respiration can be kept up for some time. That the carbonic oxide compound with colouring matter is, after a certain time, decomposed when blood is merely exposed to air, is obvious from the fact that blood which has been very imperfectly treated with carbonic oxide gas does, after 36 or 48 hours, become almost perfectly reducible, and that even when the blood has been perfectly saturated with the gas, it gradually becomes more or less reducible when kept for many days. This change is one which assuredly takes place under the influence of atmospheric oxygen. I have on three separate occasions placed fresh defibrinated blood into flasks which have been exhausted until the tension of the air has not exceeded three millimetres; carbonic oxide has then been admitted and the openings into the flask hermetically sealed. Having kept the samples of blood for many weeks, I have found on opening the flasks that, although the blood corpuscles had become disintegrated, the optical properties of the blood-colouring matter remained quite unchanged—the blood was quite irreducible. On allowing the blood to remain exposed to the air for some days after opening the flasks, the colour gradually became more and more venous, as putrefaction set in. This gradual change in the CO-compound is almost certainly due to the oxidation and conversion into CO_2—an oxidation which may be assumed to go on with infinitely greater rapidity in the living body.

Pokrowsky[2] has, indeed, shewn that animals poisoned with carbonic oxide, exhale when recovering more carbonic acid than healthy animals.

Under the influence of spongy platinum, and in presence of oxygen, carbonic oxide is gradually converted into carbonic acid, and without entering into a discussion of the possible explanation, it may be argued that as the corpuscles resemble spongy platinum in their action on peroxide of hydrogen, so do they in their relation to carbonic oxide. When a comparatively small amount, then, of the poisonous gas comes in contact with a large quantity of healthy blood, it may be assumed that this oxidation will go on so rapidly as to prevent the occurrence of any poisonous

[1] See a paper by the author in the *Proc. Royal Soc. Ed.* 1867.

[2] Virchow's *Archives*, 1864, p. 525.

symptoms, and thus we should explain Nysten's results. That under the influence of atmospheric air, blood which has been rendered irreducible by carbonic oxide, does again become normal quite independently of putrefactive changes, I have ascertained by drawing air, by means of aspirators, through solutions of blood which had been treated with carbonic oxide. The blood, under these circumstances, reacquires its characteristic properties, and becomes reducible. The solutions I have experimennted upon have varied in strength from 0·5 to 2 per cent., and the amount used has varied from 50 to 100 cubic centimetres. On passing 57445 cubic centimetres of air through 10 cubic centimetres of CO-blood, it was found that the blood-colouring matter had become reducible.

ON THE TERMINATION OF THE NERVES IN THE CONJUNCTIVA. By W. KRAUSE, M.D. Professor of Anatomy Göttingen.

In the number of this journal for November, 1866, Dr Lightbody of Edinburgh has given a most excellent description of the nerves of the cornea. This author has moreover found in the conjunctiva of the sclerotic of man peculiar bodies (Pl. V. Figs. 2, 3, and 4), in connection with the nerves. He believes these bodies to be ganglionic nerve-cells.

I am of opinion that these bodies indeed represent a certain species of nervous elements. Yet they are not ganglionic nerve-cells, but nervous bodies, in which the ends of nervous fibres terminate. I described these bodies in the year 1858, under the name of "Endkolben" or club-like bodies[1]. The club-like bodies represent indeed a peculiar form of termination of sensorial nerves. I have seen them not only in the conjunctiva, but also in various mucous membranes of the human body, viz. in those of the lips, tongue, organs of generation, etc. In all these parts they have a rounded or oval form, a nucleated membrane of connective tissue, and a granular substance in the interior. One, two, or seldom three nervous fibres approach the club-like body, lose their sheaths of white medullary substance, and terminate within the club-like body as delicate fibres without medullary sheaths with little heads.

All the mammalia, which I have examined, viz. the calf, rabbit, sheep, etc. etc. have the same club-like bodies not only in their mucous membranes, but also in the skin, as is the case with the mouse and rabbit—but with a remarkable difference. Only the ape has spheric club-like bodies, like man, all the other mammalia have club-like bodies of a more cylindrical form, and in these terminates only a single nervous fibre, not two or three. These cylindrical club-like bodies have indeed a very striking resemblance to the cylindrical axis (in which the nervous fibre ends) of a Pacinian, or, as the Germans call it, Vaterian body (Vater, who lived at Wittemberg, first described the so-called Pacinian bodies in the year 1761). Only the middle pieces of the latter are somewhat greater than the club-like bodies of the calf, &c.

Concerning these facts of human and comparative anatomy, there can indeed be no doubt, that the club-like bodies cause the sensibility of all the parts where they are situated.

In order to see the club-like bodies in the most convenient way, take a human eye-ball or the vagina of a rabbit, put it in a solution of three parts acetic acid in 100 parts water for several days, scrape off the epithelium, and examine a very fine section of the mucous membrane (of the conjunctiva near the margin of the cornea) with magnifying powers not *above* 300, because the club-like bodies are great bodies.

[1] Corpuscula nervorum terminalia bulboidea, corpuscules terminaux claviformes. See W. Krause, *Die terminalen Körperchen der einfach sensibeln Nerven*. Hannover, 1860. *Zeitschrift für rationelle Medicin* 1858. *Journal de la Physiologie*, par Brown-Séquard, 1862. T. v. Nov. XVIII. Pl. X. See also Kölliker, *Handbuch der Gewebelehre*, 1863, p. 116. 5th edit. 1867, p. 102.

ON A SYSTEM OF PERIVASCULAR CANALS IN THE NERVE CENTRES, AND ON THEIR RELATIONSHIP TO THE LYMPHATIC SYSTEM. By Prof. W. His, of Basle. Translated, with abbreviations, from Zeitschrift für Wissenschaftliche Zoologie, Bd. 15. by H. Charlton Bastian, M.A., M.D., F.L.S. with notes.

Spinal Cord. When fine transverse sections of a spinal cord hardened by alcohol or chromic acid, are submitted to a microscopical examination, they are always found to be perforated by numerous fissures, having perfectly smooth boundaries, and enclosed by a notably condensed layer of tissue. Their course and distribution is definite, and remains always the same, whether the section be made from behind forwards, or from side to side. In the white substance they run for the most part in a radiate manner. In the grey substance they are more or less regularly arranged, in the form of short and angularly bent branches. They are closer in the grey than in the white matter, but closest at the passage of the posterior cornua into the substantia gelatinosa.

It is thus evident that the fissures must owe their origin to certain definite structural peculiarities of the cord. They run in a precisely similar manner to the lymphatic fissures in the intestine and in the testicle; and experiments many times repeated on human spinal cords have proved that they may be injected like them through a simple puncture. They then exhibit a considerable resemblance to a terminal lymphatic anastomosis.

A close examination shows that the fissures are everywhere traversed by blood-vessels, sometimes attached to their walls, sometimes free on all sides. No artery or vein is seen, either in longitudinal or in transverse sections, which is not surrounded in a ring-like manner by a clear space separating it from the proper substance of the spinal cord. Around the larger vessels this peripheral space has already been observed by several investigators. The relative proportions of these perivascular spaces and of the vessels appear most beautifully when the blood-vessels of the spinal cord are first injected in the ordinary way, and then the perivascular spaces by means of a puncture. One can also fill the perivascular spaces from the blood-vessels, when these are ruptured by the injection: the extravasation so produced will spread widely through the perivascular canals, and form everywhere, in this way, a cylindrical envelope around the vessels.

Lastly, very instructive preparations may be obtained by the use of nitrate of silver, whether one injects the blood-vessels of the cord with a solution of silver, or simply forces the solution in through a puncture. If in the first case the force of the injection be sufficient, the fluid makes its way out of the vessels into the surrounding spaces and tinges their walls; likewise one obtains, in the second case, a tinging of the vessels as well as of the walls of the canals.

All the preparations produced by these different methods permit of the same conclusion, that the perivascular canals are constant structures, which are neither produced by extravasations, nor capable of being explained by a collapse of the blood-vessels. The calibre of the canal is always considerably wider than that of its contained blood-vessel, mostly exceeding it two, three, or even four times. No connection exists between the wall of the vessel and the wall of the perivascular canal. Though the vessels, and especially the arteries, possess a proper adventitious connective tissue-coat, they lie perfectly free within their enclosing canal, and often may be seen to run in an undulating manner, where the boundaries of the outer tube are distended. From nitrate of silver preparations the walls of the perivascular canals appear to be formed of a striped fibrous basis substance, very similar to the walls of the fine splenic veins[1]. Owing to the relations of the

[1] Robin, who first described this structure (*Compt. Rend. de la Soc. de Biolog. Paris*, 1855, and Brown-Séquard's *Journal*, 1859), spoke of it as a delicate hyaline membrane; and from numerous observations of my own I believe this to be its normal condition, though very frequently it does undergo a fibroid change, in which state it would answer to the description given above. Professor His did not seem to be aware of the observations of Robin, but after much careful examination I am able to state that all the perivascular spaces in the brain and spinal cord are occupied by perivascular hyaline sheaths such as were described by Robin, although the latter believed these to be far less extensive, and that they existed only around *some* of the small vessels

said spaces to the blood-vessels, the peculiarities of their disposition and distribution are easily comprehended. The larger of them follow the arteries and veins, which, at distinct points, penetrate from the pia mater into the white substance: with the vessels they divide, communicate with one another, and form arches within the grey matter. In the grey matter, which, as is known, is much richer in vessels than the white, the perivascular-canal system also assumes another character: it becomes much closer, and the anastomoses are twice as fine and much more abundant, so that in fact the grey substance contains a perfectly sponge-like network.

Brain. Fine transverse sections of a hardened brain, having its vessels injected or otherwise, show that all the blood-vessels, arteries, veins, and even capillaries, are surrounded by a clear space, broadest in the case of the larger vessels, but in all cases quite sharply defined externally. In transverse sections the vessels are seen to be surrounded by a ring-like space, and in parallel sections the space is seen on each side of the trunk of the vessel, and follows it in all its ramifications. Very frequently one finds further that in fine transverse sections the vessel has dropped out from its surrounding space, and these remain simply as round or oval loculi in the tissue. That the above described relations are not simply the results of the hardening is learned from the examination of the fresh brain. If a thin section is made from such a one, for instance, just beneath the surface of the hemisphere, and examined with a low power, one sees here also with ease round and oval spaces which are partly quite empty and partly undoubtedly occupied by vessels. Even without the microscope, by the naked eye, or at least with a lens, similar observations may be made. If a section be made of fresh brain and examined closely (more particularly when under water), one may see in many places torn ends of vessels stand out from the surface of the section, each of which projects from a small space in the tissue, which it partly fills. Similar things are seen when the section is made parallel to the direction of the vessels, and most excellently in magnified sections of parts of the brain which contain somewhat larger trunks, such as the cerebral ganglia, Thalamus opticus, and Corpus striatum. At the borders of both, directly under the Tænia semicircularis, there runs a vessel which is especially to be recommended on this account.

These various observations teach, that, as in the spinal cord so also in the brain, the blood-vessels are surrounded by perivascular canals, with the walls of which the adventitious coat of the vessel is in no way connected. This explains also why one can generally so easily succeed in pulling out whole trees of vessels from the brain, by a simple pull with the forceps.

The perivascular canals of the brain, like those of the spinal cord, are capable of being injected. When a separate portion of brain, especially of the grey substance where the vessels are largest, is punctured with a sharpened canula, and fluid is injected, a tree-like network of ramified canals is filled in the immediate neighbourhood of the puncture. Under the microscope one discovers that these canals everywhere surround the blood-vessels, and that they are quite sharply defined externally. This, together with their regularity of calibre, evidently shows that they are by no means the results of extravasations, but are due to the filling of pre-existing structures.

The width of the perivascular canals of the brain increases with the size of the blood-vessels themselves; but here also they are, as a rule, from twice to four times[1] as wide as these last; the largest injected canals measuring as much as 15‴, and the finer from ·004‴—·006.‴

We come now to *the relation of this apparatus of canals to the Lymphatic system.* If an injection of the network we have been describing be placed side by side with injected networks which are undoubtedly lymphatic, it is seen fully to accord with these last in respect of the width of the canals, the manner in which they are connected, and the lack of an independent fibrous membrane[2]

which did not exceed ⅓ mm. in diameter. The hyaline sheaths are in no way adherent to the surrounding nerve-tissue, and invariably accompany the vessels when these are pulled out from the nerve substance. Prof. His having carried on his observations principally by means of injections speaks little of the sheaths themselves, but much of the perivascular spaces which they enclose.—Tr.

[1] So far as I have seen, this great relative size of the perivascular sheath is met with only in the central ganglia of the brain, whilst in other parts the sheath is rarely more than twice the diameter of the vessel. In the widest tubes of the corpus striatum and optic thalamus I have generally found one large vessel and several smaller ones.—Tr.

[2] As may be seen by our last note we do not consider this statement quite correct.—Tr.

separable from the surrounding tissue. It is no doubt difficult, even with the aid of nitrate of silver, to display epithelium within these canals, since the silver precipitates which form are taken up with the greatest rapidity and only separate themselves again to a slight extent. I have, however, been able to discover most unmistakeably the characteristic appearance of epithelium[1] in different preparations of the spinal cord, though also, as yet, only in the larger canals. It will only be fully settled as to the lymphatic nature of our net-work of tubes when we are able to demonstrate its connection with undoubted lymphatic vessels.

Amongst the anatomists, who, in the earlier ten years of the present century, employed themselves in the injection of lymphatics, certainly none succeeded in filling lymph-spaces within the brain or spinal cord: on the other hand, Fohmann, as well as Arnold, have seen and figured undoubted lymphatic vessels in the pia mater (and arachnoid ?); and these are not in fact very difficult to display in man. It is sufficient to make a puncture close to one of the larger blood-vessels of this membrane, and to inject with a gentle force in order to fill them over a wide area. The injected material pushes forwards into the small canals, which anastomose with one another in the richest manner, so that even there is an appearance here and there, as though the injection spread like an unbroken sheet. When an already injected pia mater is examined away from the brain, and submitted to a low power of the microscope, one convinces oneself that the injection has really moved in closed canals (from $\frac{1}{10}-\frac{1}{4}'''$ in diameter)[2].

But are the perivascular canals of the brain in communication with the lymphatics of the pia mater? When the cortical substance of the brain is injected through a puncture with a very weak continuous force, after some time the injection following the vascular trunks reaches upwards to the surface of the brain. Arrived under the pia mater it disperses itself quickly on all sides in small streams, which soon unite with one another. When the injection is quietly pushed still further, one reaches after some time a second tissue layer above the deepest, which completely covers the small points of brain surface that had remained visible. The first spreading distribution of the injection lies between the pia mater and the surface of the brain; the second, on the other hand, in the pia mater itself, and indeed within the before-described lymphatic canals of the same. When the pia mater is pulled away from the surface of the brain, the injection matter is found between the two; and when this is washed from the surface of the brain only a few points remain behind, corresponding with the places of exit of the blood-vessels, whilst on the other hand the pia mater after washing shews distended lymph-canals.

It is thus so far certain that the lymph-canals of the pia mater can be filled from the perivascular canals of the brain. A wide system of lacunæ, separating the brain from the pia mater, appears as an intermediate bond of connection. I confess that in the first place I was not inclined, on account of their width, to consider the spaces beneath the pia mater (unbroken save by traversing blood-vessels) as pre-existing lymphatic spaces, since they rather seemed to me to be artificial in their origin. But the consideration that they immediately make their appearance, even in the most excessively careful injection, and the still more weighty fact that the lymphatic canals of the pia mater are filled from them, leaves me at last no doubt as to their nature. By a direct puncture underneath the pia mater one naturally fills the same spaces, and also, in this case, obtains a speedy passage of the injection into the canals of the pia itself. Lastly, the extension also of this system of epicerebral lacunæ does not militate against their being lymphatic spaces. When we consider how, amongst the Amphibia, the whole outer skin is separated from the underlying tissues by enormous lymph-sacs,

[1] My own observations also lead me to believe that these tubes have an imperfect epithelial lining. Round or oval nuclei, precisely similar to those on the surface of the arachnoid, are to be seen distinctly on the inner surface of these tubes, but in both situations the surrounding scale is alike difficult to recognize. These nuclei in many places are very abundant, and lie in the perivascular space detached from its wall, as Robin (*loc. cit.*) has well represented. Robin speaks of the resemblance of the cells to lymph corpuscles, but I think, from their identity in size and form, there cannot be a doubt that they are produced by a proliferation of the lining epithelial nuclei.—Tr.

[2] From my own microscopical observations I have fully convinced myself that the majority of the vessels in the pia mater are surrounded by sheaths similar to those met with in the substance of the brain and spinal cord. I have not been able to demonstrate them, however, around the main trunks, and how the sheaths terminate I have also been unable to ascertain. However doubtful it may be whether these sheaths are in reality lymphatic tubes, there cannot be a doubt that such structures do exist around the greater number of the vessels in the pia mater.—Tr.

which, like the lymphatic spaces, are only interrupted in those places where vessel or nerve-bearing fasciculi of connective tissue stretch across towards the skin, we can no longer regard as so surprising the supposition that the whole area beneath the pia mater should be a lymphatic space.

The examination of good longitudinal sections through the brain and its membranes affords an excellent check to the estimation of the results afforded by injections. If a longitudinal superficial section of a hardened human brain, made with a sharp knife and without sawing, be examined without a covering glass, the following parts are displayed: the pia mater, displaying itself as a thin tissue layer, is completely separated from the surface of the brain, and only connected with it by means of fine threads—the blood-vessels. Into the epicerebral space found underneath this, those canals open which accompany the blood-vessels of the brain as far as its surface[1]; sometimes the opening here is even slightly widened out in a funnel-like manner. The thin layer of the pia splits itself in many places, and shews large, smooth walled, defined spaces in which blood-vessels lie, in such a manner, however, that the canals are only partially filled by them even when the vessels are injected. These spaces are the before described lymph-canals of the pia, and their communication with the epicerebral lacunar spaces takes place in those situations where vascular trunks issue from them, in order to go to the brain. Externally, the pia is connected with the arachnoid by means of numerous connective tissue laminæ, and the arachnoid, moreover, displays itself as a thickened surface layer. Between the subarachnoid spaces, however, and the lymph-canals of the pia mater no connection exists.

I think I am able to maintain for the brain, then, that the perivascular spaces are lymph spaces, which open on the surface at once into the epicerebral lacunæ, and thence into the lymphatic tubes of the pia mater. Arnold's deep lying lymph network appears from his description to correspond with the epicerebral space; the two upper networks, on the contrary, which he describes belong, as I think, to the pia mater itself, and are only here and there capable of being separated from one another.

The decision with reference to the spinal cord, is more difficult than for the brain. It is known that no anatomist as yet has succeeded in filling lymphatics proceeding from the spinal cord; and I have not been more fortunate than my predecessors. If one injects the spinal cord through a puncture with a gentle and continuous force, the injection soon appears upon the surface at several small points. Arrived beneath the pia, it distributes itself however in streams which anastomose abundantly. When the injection is allowed to flow for a longer time under an equable pressure, no other result is obtained. I so contrived as to place portions of an unopened spinal column in a weak saline solution, and then directed an injection into the cord through a puncture, and under a weak mercurial pressure. The injection flowed freely from the opposite cut surface of the cord out of the spaces around the central vessels, and from those under the pia mater, but did not fill even the trace of an outgoing trunk. In this respect also is the condition different here from what it is in the brain, namely, that the injection never runs into the pia mater itself, but always remains between it and the cord. Even the microscope shews, moreover, no perivascular spaces around the vessels of the spinal pia mater.

It seems really that direct outgoing lymphatic vessels from the spinal cord are wanting. But by this of course it is not said that the perivascular and epispinal spaces of the cord have nothing to do with the lymphatic system. All their analogy with the above-described structures of the brain militates against this. It seems to me to appear much more probable, that the flow takes place only indirectly from the lymphatic spaces of the cord, since the injection mounts up partly under the thick pia, and partly in the wide spaces around the central vessels, to the brain, and thence takes its further course. Another indirect flux can take place into the subarachnoid spaces. Under the influence of increased force the solution will filter back through the pia mater, and can mix itself with the cerebro-spinal fluid.

[1] I think this statement needs verification. Certainly in very many cases, the perivascular sheath encloses the vessels uninterruptedly between the superficial parts of the brain and the pia mater, and I have never myself seen the sheath terminate at the surface of the brain. If it does so there must be an amalgamation, at the mouth of the infundibuliform opening, of the hyaline membrane with the nerve tissue, by means of the neuroglia. My own impression is that this does not take place, and I think we require more evidence before we can be quite satisfied as to the existence of this system of epicerebral lacunæ, notwithstanding the careful manner in which Prof. His seems to have conducted his investigations.—Tr.

The whole distribution of the perivascular canal system is unquestionably a subject of the greatest physiological interest. In most organs of the body, and above all in the membranes, in the muscles, and in many glands there is found an abundance of connective tissue capable of imbibition, which immediately takes up the fluid exuding from the blood, and holds it ready for the disposal of portions of tissue undergoing rapid nutritive changes, such as muscle and nerve fibres, gland cells, &c. From the connective tissue, the overflow out of the circulating fluid first reaches the lymphatic radicles, which, after the fashion of drainage tubes, permeate the organ. In the central nervous organs this intermediate tissue, as is well known, takes so inconsiderable a place that for a long time it was totally overlooked. In the place of that abundant, spongey, basis substance, which is so prominent in other parts, we find here only a fine and tender network, which insinuates itself into the small interstices of the proper nerve tissue. In this form at all events, the intermediate tissue appears little fitted to fulfil the function of a general receiver of exuded fluid, wherefore the lymphatic system is now so disposed as to compensate for this want, inasmuch as canals are produced around the blood-vessels, in which the nutritive plasma at first collects, and then gradually disperses. A similar disposition is found in other organs of the body: according to the investigations of Ludwig and Tomsa, in the testicles; and from McGillivray's latest observations, in the liver.

The same receptacles in which the nutritive fluid of the central organs is stored up, serve, moreover, as structures of a protective nature. It is well known that extensive arrangements are met with, in order to modify the mechanical influence of the circulation of the blood upon the brain and spinal cord. The presence of the cerebro-spinal fluid protects the brain as a whole from the almost inevitable force of the filling of the larger arteries and veins. By the winding course of the brain arteries before their entry into the cavity of the skull, by their connection with one another, and by the arrangement that all the vessels divide into fine branches in the pia mater, on the outer surface of the brain, it is brought about that the arterial blood flows only with a proportionately gentle force through the internal substance of the brain and spinal cord, and that it can manifest only in the most moderate manner the periodical oscillations of force due to the pulse. But all this appears to be insufficient to protect the brain substance against mechanical action on the part of the vessels. We see, in addition, that the whole intracerebral and intraspinal vascular system is separated by a well-marked envelope of fluid from the proper substance of the brain and spinal cord: a fluid envelope which communicates with extensive reservoirs on the surface, and into which the fluid can empty itself on the occurrence of the least difference of pressure[1]. Such an arrangement is indeed fully adapted to reduce to a minimum the mechanical action of the blood-vessels upon the nervous substance. What the liquor cerebralis does for the brain as a whole, that the perivascular fluid does for each separate portion of the central organs. With the spaces which contain the cerebro-spinal fluid of course these canals do not communicate; but it is obvious that a higher pressure in the spaces must transmit itself to the contents of the lymph reservoirs, and *vice versa*.

The pathological side of the question we are considering, I leave for the benefit of others; I allow myself only two observations, one of which is this, that the obviously marked difference in consistence of the central organs, on section, may be referred in great part to the more or less rich abundance of the perivas-

[1] To insure the complete and perfect action of a mechanism of this kind it would certainly be necessary that this perivascular system of canals should be in communication with other extra-cranial canals, since in a case of general congestion of the brain the organ could only be relieved from undue pressure by the displacement of a proportionate quantity of the perivascular fluid, not only from the substance of the organ itself, but also actually out of the cranial cavity, as there would be just the same reason for its displacement from the pia mater as from the brain substance. On the diminution of vascular pressure the fluid would again soon accumulate in the perivascular spaces. Perhaps almost the same relief from tension might be brought about by the driving of the extruded cerebral perivascular fluid into reservoirs in connection with the spinal chord which admit of more distension, owing to the much greater proportional size of the canal containing the spinal cord. So that if there are no outgoing trunks from the cranial cavity, and this system is not a branch of the lymphatic system, we should be compelled to look upon the perivascular canals as having a simply mechanical and protective function, and to regard the more distensible spaces around the spinal cord as the complemental reservoirs, into which the excess of cerebral perivascular fluid might be driven in time of need.—Tr.

cular fluid. A second observation is, that in states of chronic congestion, the perivascular spaces may become permanently widened; I draw this conclusion from the fact that in an old drunkard who died in an asylum, I found the canals in question of the spinal cord most unusually wide and capable of being easily injected[1].

The subject has also its developmental aspect. The paradox, namely, that the brain and spinal cord, being vascular organs, are developed not from the middle but from the outer germinal layer, wholly loses its point when we consider that the vessels of this part penetrate into it from the pia mater (which is an offspring from this middle germinal layer), as a system formed altogether separately and standing only in contiguity with the proper nerve substance: the central nervous organs on this account enter into the category of organs of mixed structure, in which the glands especially are included, and also the teeth, according to Kölliker's recent observations. The Neuroglia itself appears from this, also, in another light, since it is nowhere in connection with the pia and the blood-vessels given off from it, therefore one would be mistaken in looking upon it as a connective tissue (with which also it does not rightly accord histologically), and we shall have to regard it as a tissue of a special kind.

It appeared from my former investigations on the retina, that the relation of the blood-vessels to the surrounding tissue is altogether similar: as in the brain there also perivascular canals are present, concerning which I purpose to treat in another communication.

REVIEWS AND NOTICES OF BOOKS.

Shädel nordostafrikanisher Volker, von Dr Alexander Ecker, Professor der Anatomie in Freiburg, reprinted from the Abhandl. der Senckenb. Gesellsch, B. vi. and sold by C. Winter, Frankfurt-am-Main. The collection of Skulls of North East African Negroes, made by Professor Bilharz of Cairo, having been placed in the Museum of Freiburg, Professor Ecker publishes measurements and drawings of some of those which were traced to have belonged to members of particular tribes. These tribes vary a good deal in many respects; and the crania likewise vary. He does not draw any particular inferences, but promises further anatomical details in a future treatise.

Anteckeningen over de outleedkunde van den Carpus der Zoogdieren, by W. T. Vrolik; an academical exercise, at the University of Leiden, for the degree of Doctor in Natural Science, by a son of the late eminent professor of that name. It gives a careful description of the carpus of Mammals intended to supplement the work of Gegenbaur (Untersuchungen zur vergleichende Anatomie) which treats rather lightly on this subject. The author commences with a review of the opinions of Vicq d'Azyr, Owen, St Martins, Humphry, and others.

Historical Sketch of the Edinburgh Anatomical School, by John Struthers, M.D., Professor of Anatomy in the University of Aberdeen. As early as 1505 the practical genius and good sense of the Scotch, requiring that every applicant for admission to the Incorporation of the Surgeons should "knaw anatomea nature and complexioun of every member In manis bodie," gave "anis in the yeir ane condampnit man after he be deid to mak anatomea." Still, owing to the unsettled state of the country not much progress was made until by the three, or, we might say, the four Monros the foundations of the school were laid, the reputation of which has been so well maintained by their successors, the Bells, Barclay, Knox, and not least, the late eminent professor. Professor Struthers' short 'Sketch' of the history of the School and of these distinguished men is very interesting.

[1] For an account of the important changes taking place in this system of canals in *Tubercular Meningitis*, see *Edinb. Med. Journal*, April, 1867.

Fecundity, Fertility, Sterility, and allied Topics, by J. Matthews Duncan, M.D., Lecturer on Midwifery, Edinburgh, 8vo., Adam and Charles Black. The questions connected with these topics are very carefully considered, and numerous tables are given collated chiefly from Scottish sources. The vigour of the female reproductive system is found to wax till the age of about 25, and then to wane; this being shewn by fertility as well as by the weight and length of the children. In opposition to this it is remarkable that the fertility of mothers in twins increases up to the age of 40; and the frequency of twin-bearing increases with the number of the pregnancy. The concluding part of the work on the 'duration of pregnancy' is particularly valuable. In many of the elaborate essays which have been written on this subject an important source of error lies concealed, the author thinks, in a want of clear discrimination between insemination and conception; and he believes "that a full comprehension of the bearings of this distinction will go far to equalise the discordant views as to the term of pregnancy in the human female, and to account for many of the so-called cases of prolonged gestation," p. 331. The commencement of pregnancy must be dated from conception; and it is important therefore to ascertain what length of interval may exist between it and insemination. This period of time, whatever it may be, must be subtracted from all the supposed crucial cases of the duration of pregnancy; and it is difficult to estimate it with certainty. The duration of the fertilizing property of the semen is probably limited only by the term of life of the spermatozoa within the uterus, which observation in various mammals shows may extend to many days or even to weeks. He admits occasional protraction of pregnancy, but discredits most of the recorded cases, partly, because there is no mention of the child being bigger than usual.

W. Kühne. *Lehrbuch der Physiologischen Chemie* (Text-book of Physiological Chemistry). Leipzig, Engelmann, 1866.

Lehmann's Physiological Chemistry not only is now thoroughly out of date, but always was a most troublesome book to use on account of the faultiness of its arrangement. For everything almost, it had to be consulted in at least three places. The work of Gomp-Besanez, though valuable for many things, especially for its tabular statements and its richness in analytical detail, has the fault of containing too much chemistry and too little physiology; a great deal of the first part of the book is out of place, while other portions are far too meagre. Besides it too is already getting old. There is still in many minds too great a tendency to look upon physiological chemistry as a distinct branch of chemistry with abstract laws of its own drawn from distinct phenomena and studied in distinct ways, whereas the whole progress of science most clearly shews that it ought to be regarded as a mere collection of concrete chemical problems which have to be solved by the special application of general chemical principles. A text-book of physiological chemistry ought to take for granted that the reader is fairly acquainted with general chemistry, with the chemical history of those elements and compounds which happen to be found in the animal body and so go straight to the particular problems, the special chemical transactions which make up so large a part of what we call physiology.

Such a book is the one by Dr W. Kühne. He wastes no time in reproducing from a chemical manual chapters on copper, or stearin, or albumin, but plunges at once into the chemistry of digestion, which he discusses in the very fullest manner, especially developing the most recent researches and theories. He next treats of the chemistry of the solid and fluid tissues of the body, and finishes with the excretions by lungs, skin, and kidney. In other words, the matter of the book flows in the same way that matter flows through the living body.

A very fair idea of the work may be gained by a perusal of the chapter on "The Chemistry of Muscular Tissue." The various extractives either nitrogenous, as 'kreatin,' &c. or non-nitrogenous, as 'paralactic acid,' 'dextrine,' &c., have but little space devoted to them, and that is chiefly taken up in discussing their rational chemical constitution with a view to the discovery of their physiological genesis. The account of the proteid constituents, on the other hand, is much more complete; and the author here expounds his views concerning the dependence of the phenomena of rigor mortis on a coagulation of the fluid muscular substance. He speaks of muscle-plasma giving rise by coagulation to muscle-clot or myosin and muscle-serum. We say 'his views,' but we suppose that by this time we may regard them as generally accepted by physiologists. The characters of 'myosin,' its relations to 'syntonin' and the chemistry of rigor mortis are fully

gone into. Under the head of "Physiological Function of Muscle," the author discusses, as far as present knowledge will permit, the chemistry of stimulation and the chemical changes undergone by muscular substance when it is thrown into activity, to wit the generation of paralactic acid, of carbonic acid, of kreatin and sugar (probably), frequent reference being made to the well-known work of Ranke. Sections, on "The Influence of Blood over Muscles" and on "The Venous Blood coming from Muscles" lead to a review of the "Changes in the total metamorphosis of the Body induced by muscular activity," in which a leaning towards the theory of a non-nitrogenous source of muscular power is very observable.

It will at once be seen from this brief sketch that the character of the book is, as we have said, essentially physiological. The chapter on muscle is not more so than any other portion. For instance, the chief part of the chapter on Blood is taken up with a full account of Hæmoglobulin (Hæmatoglobulin) its derivatives (Hæmatin, &c.), its relation to gases, its oxidation and reduction, its optical properties, &c., while the developement of fibrin from the two fibrin generators paraglobulin (fibrinoplast) and fibrinogen is of course described at length. We might particularly call the attention of the reader to the discussion touching the relations of parglobulin (Schmidt's globulin) to the proteid constituent of Hæmoglobin, to globulin itself, and to the other proteid substances of the blood.

In short, we may venture to say, that if any one who has seen little of the progress of physiological chemistry during the last five or ten years, who has sat at the feet of Lehmann only, takes up this work of Kühne's, the book will seem to him strange and new from beginning to end.

One fault it has, a glaring one. It gives no references. Should it appear in an English dress, and we have some reason for hoping that it soon will, we trust that care will be taken to supply this great lack.

C. Eckhard. *Experimental Physiologie des Nervensystems* (Experimental Physiology of the Nervous System). Giessen, 1866.

This is not a record of new experiments bearing on the physiology of the nervous system, but simply a plain and lucid exposition of the present state of our knowledge in this branch of the science of life, written in order to furnish the physiological student with a general introduction to the whole subject. A preliminary chapter discusses the electrical laws and describes the electrical apparatus, a knowledge of which is necessary as a preparation for physiological studies. The physical qualities of nerves are then considered, and afterwards their physiological properties. Next follows a brief outline of the scanty information that experimental investigation has brought us concerning the functions of the brain, succeeded by more detailed accounts of some of the cerebral nerves, especially the pneumogastric. The spinal cord is treated of in reference to its laws of conduction, its reflex and tonic actions, its so-called psychical functions, and the subordination of its activity to the inhibitory mechanism of the brain. Several particular reflex phenomena of the brain and cord are then discussed, as well as the functions of certain spinal nerves; and a section on the physiology of the sympathetic closes the book.

The author states in his preface that he has striven to be brief, clear, and critical; we may congratulate him on having succeeded. As far as we can see he has missed no important points, and yet has avoided the error of profuse accumulation. He has been so brief as to condense the whole matter into about three hundred pages, and so clear as an Englishman, of the typical kind, would hardly think a German could be.

With reference to the controversy as to the action of the pneumogastric on the beat of the heart, Lister and Schiff, followed by Moleschott, as is well known, maintain that while powerful stimulation of the pneumogastric lessens the frequency of, or altogether suspends the cardiac rhythm, a milder application has the contrary effect of increasing the number of beats. Pflüger, however, with V. Bezold and others, distinctly denies that stimulation of the pneumogastric, be it weak or strong, or moderate, can ever lead to an increased frequency of the heart's beat. Here is a plain straightforward contradiction, on which an editor can be led to decide by nothing, except by researches of his own. Eckhard very emphatically sides with Pflüger, and discards the theory of Schiff, that the phenomena of inhibition are due to exhaustion of the pneumogastric fibres. Bearing on this subject, we find recorded an instructive experiment. Schelske had main-

tained, that when a frog's heart has been brought to rest in diastole by exposure to a temperature of 30—33° C., stimulation of the pneumogastric will produce a distinct beat. The inference is that the pneumogastric is the motor nerve of the heart. On repeating the experiment, Eckhard found that no beat could be obtained, except when the electric current which served as stimulus was so applied *that it had an opportunity of escaping into the substance of the heart.*

With regard to the automatic action of the heart itself, Eckhard comes to the conclusion, that one ought to look upon the heart not merely as an ordinary striated muscle entirely dependent in its contractions on certain ganglia, but as a mass of contractile tissue of a peculiar kind contracting in a peculiar way, though influenced in an obscure manner by its nervous constituents. In this view he rests chiefly on three grounds. 1. That in the heart (of vertebrata at least) ordinary tetanus cannot be produced. 2. That a piece of ventricle, in which no ganglia can be found by the strictest search, may be thrown not into local contractions, but into a pulsation by a wholly insignificant mechanical stimulus. 3. That pieces of ventricle wholly free from ganglia when enclosed in a constant current exhibit a regular rhythmic pulsation, an orderly sequence of systole and diastole. He says (and to our minds seems very just in saying) that these properties are inconsistent with the view that the cardiac tissue is ordinary muscular tissue.

The work is strictly experimental; theories and views are carefully excluded. The chapters on the electrical phenomena of nerves and on the laws of innervation are the clearest and most satisfactory we remember to have seen anywhere. References to authorities are given freely, and the very latest researches are included. The student of physiology will find it, what it professes to be, a most useful and trustworthy introduction to the study of the nervous system.

QUAIN'S ANATOMY, 7th Edition, edited by Professors Sharpey, Allen Thompson, and Cleland. That this would be the best compendium of Anatomy in our language we had every reason to expect from the eminent names upon the title-page; we need only say that the work is well worthy of them. Presenting, as it does, to the ordinary student the most recent researches in microscopical and developmental anatomy in a clear simple manner with abundant good illustrations, such a work will do much to diffuse a better mode of studying anatomy and to elevate the scientific character of our students. It is of the same class with HENLE'S ANATOMIE DES MENSCHEN, though it contains less of original matter than is to be found in that excellent HANDBUCH.

REPORT ON THE PROGRESS OF ANATOMY, by Prof. TURNER[1].

THE attention of anatomists has recently been directed to a structure about the size of a small pea, situated at the tip of the human coccyx, which was named by its discoverer the COCCYGEAL GLAND. It was first described by von Luschka of Tübingen, as composed of closed follicles filled with cells, and intimately connected with the terminal twigs of the middle sacral artery. He associated it with the pituitary gland. Julius Arnold, of Heidelberg, has since shewn that it ought rather to be regarded as composed of tuft-like dilatations of the terminal twigs of the middle sacral artery, the muscular and epithelial coats of which are very materially thickened. The latest writer on the subject, G. Meyer of Göttingen (*Henle u. Pfeuffers Zeitschrift*, 28th Vol. p. 135, 1866), agrees with Arnold in considering the bladder, or funnel-like spaces, seen in sections through the so-called gland, to be arterial dilatations; but the cellular contents, which Arnold regarded simply as the hypertrophied tesselated epithelial lining of the arteries, Meyer describes to be of various forms and sizes. Irregular polygonal flattened cells with two long processes are sometimes seen. or polygonal cells whose angles stick out in a pointed manner, or pear-shaped cells, and lastly cells which are quite round, and have the greatest likeness to lymph corpuscles. The nerve fibres of the gland consist of double contoured and pale fibres, they form a very delicate network, the pale fibres seem to end in the muscular coat of the dilated arteries, the termination of the double contoured fibres he could not trace. Neither he nor Arnold were able to see the ending of nerve-fibres in nerve-cells which Luschka described. Meyer examined the tails of the dog, rat, and mouse, and found no analogous structure there; but in the cat, opposite the 2nd and 3rd coccygeal vertebra, in the space between the musculus caudo-analis and the spine, he found a structure apparently of the same nature, though he admits he was unable to trace branches of the middle sacral artery into it. He also refers to Krause's observations on the occurrence of this body more largely developed than in man in Macacus cynomolgus, not at the end of its tail, but opposite the pelvic outlet. From the structure of the body Meyer is inclined to place it along with the caudal hearts, or retia mirabilia, which are appendages of the arterial system in many animals.

Adolf Kühn in Göttingen describes (*Henle u. Pfeuffers Zeitschrift*, 28th Vol. p. 147, 1866) two cases in which ACCESSORY SUPRA-RENAL CAPSULES were met with. Both occurred in adult female subjects. In one case the left capsule had the accessory structure seated on its anterior surface, and two small additional bodies were attached by connective tissue and blood-vessels to the hilum of the right capsules. In the second case the accessory body was seated on the anterior surface of the right capsule, and the left capsule had one accessory body attached to its hilum by connective tissue. Kühn then gives a historical account of the cases in which accessory supra-renal capsules have been described.

A. Gruenhagen (*Henle u. Pfeuffers Zeitschrift*, 28th Vol. p. 176, 1866) reviews the anatomical evidence which has been advanced as to the existence of a DILATATOR PUPILLÆ muscle in the Iris of man and the mammalia, and concludes, from many observations which he has personally made, that no such muscle has been demonstrated. He also denies the existence of this muscle in the iris of the frog. He does not seem to have been acquainted with the observations of Joseph Lister on the same subject (*Quarterly Journal of Microscopical Science*, 1853. p. 8), who has described in the iris of the horse distinct muscular fibres diverging from the sphincter pupillæ towards the circumference of the iris, and quite distinct from the muscular coat of the arteries.

H. von Luschka describes (*Henle und Pfeuffers Zeitschrift*, Vol. 26, p. 300, 1866) a characteristic specimen of HYMEN FIMBRIATUS. He points out that the fimbriæ are studded with numerous pyramidal, globular, and cylindrical papillæ.

W. FINGER describes the MODE OF TERMINATION OF THE SENSORY NERVES IN THE MUCOUS MEMBRANE OF THE GLANS PENIS AND CLITORIS. (*Henle u. Pfeuffers Zeitschrift*, Vol. 28, p. 222, 1866.)

H. Meyer of Zurich (*Reichert u. du Bois Reymond's Archiv*, Heft VI. 1866) contributes two Memoirs on the MECHANISM OF THE HUMAN SKELETON, in which he discusses the carpal articulations and the movements of flexion, extension, pronation and supination.

[1] Prof. Turner much regrets that the unusual demands upon his time consequent on the illness and death of Professor Goodsir have prevented his completing this report.

L. Stieda of Dorpat describes the case of a woman, aged thirty, in whom a pair of CERVICAL RIBS sprang from the 7th cervical vertebra (*Virchow's Archiv*, July, 1866, p. 425). Except that the left cervical rib was ossified to its vertebra, whilst the right was articulated to it by a moveable joint, both ribs closely resembled each other. In both a head, neck, tubercle, and body, were found; the anterior end of the body was pointed and connected by a ligament to a plate of cartilage attached to the anterior end of the first thoracic rib. An external but no internal intercostal muscle passed between the cervical and first thoracic rib. The subclavian arteries had been removed so that Stieda could not determine their relations. The thoracic vertebræ and ribs and the lumbar vertebræ were normal in number. The paper concludes with a brief historical account of the cases previously recorded.

W. Gruber (*Reichert u. Du Bois Reymond's Archiv*, Heft v. 1866) records several examples of SECONDARY CARPAL BONES IN MAN. John Davy (*Proc. Roy. Soc. London*, Dec. 6, 1866) records a number of additional observations ON THE BONES OF BIRDS. His enquiries embrace not only the bones of those birds in which the marrow is persistent throughout life, but those in which the marrow is replaced by air.

Researches on the MINUTE STRUCTURE AND DEVELOPMENT OF THE TEETH are contributed by H. Hertz (*Virchow's Archiv*, November 1866, p. 272). His observations were made on embryo pigs, dogs, and calves.

Notes on the ANATOMY OF THE INGUINO-CRURAL REGION are communicated by M. Nicaise to the *Archives générales de Médicine*, July and December 1866. His descriptions are clear and ample, but embrace no new facts of importance.

In an important memoir on the myology of Echidna hystrix (*Trans. Linnœan Soc.*, 1866, Vol. 25), St George Mivart enters into a general discussion on the SERIAL HOMOLOGY OF THE FORE AND HIND LIMBS.

W. Dönitz (*Reichert u. Du Bois Reymond's Archiv*, 1866) gives an anatomical description of a DOUBLE MONSTER.

A. Böttcher (*Virchow's Archiv*, 36th Vol. 1866), communicates a series of researches on the RED-BLOOD CORPUSCLES IN THE VERTEBRATA. W. Gruber (*Reichert u. Du Bois Reymond's Archiv*, Heft. VI. 1866) describes the VALVULAR ARRANGEMENTS in the VENA AZYGA AND ITS BRANCHES. Eberth and Belajeff (*Virchow's Archiv*, September 1866), communicate observations on the DISTRIBUTION OF THE LYMPHATIC VESSELS in the endocardium, pericardium, and muscular substance of the heart.

H. Hirschmann and Chrzonszczewsky (*Virchow's Archiv*, 36th Vol. July 1866, p. 335) communicate some additional observations on the MORE MINUTE STRUCTURE OF THE TEXTURE OF THE LUNGS.

C. B. Reichert (*Archiv*, Heft VI. 1866) concludes that the presence of the so-called BILE-DUCT CAPILLARIES between the liver-cells, as of other wall-less preformed spaces, such as the roots of lymphatic vessels, is not proved, and moreover not at all probable.

H. C. Bastian (*Quart. Journ. Microscop. Science*, Vol. 6, 1866, p. 86) gives an account of the so-called PACCHIONIAN BODIES, and supports the view that they spring from the cerebral layer of the arachnoid membrane. J. Langdon Down (*Medico-Chi. Trans.* Vol. 40, 1866) records a second case in which the CORPUS CALLOSUM WAS DEFECTIVE. W. Manz, in Freiburg (*Henle unde Pfeuffers Zeitschrift*, 28th Vol. p. 231, 1866), describes the structure of the GANGLION-CELLS IN THE RETINA OF THE FROG.

Leopold Besser (*Virchow's Archiv*, 36th Vol. July, 1866, p. 305) describes the mode of origin of the NERVOUS STRUCTURES IN THE CENTRAL ORGANS OF THE HUMAN NERVOUS SYSTEM. W. Moxon (*Quart. Journ. Microscop. Science*, October 1866) records an observation made on the mode of TERMINATION OF A MOTOR NERVE, but the conclusions arrived at in this paper are disputed by Lionel S. Beale in the *Medical Times and Gazette*, Jan. 19, 1867.

Wilson Fox (*Phil. Trans.* 1865-66) in a paper on the DEVELOPMENT OF STRIATED MUSCULAR FIBRE, regards it as produced by a definite series of changes commencing in the cells of the early embryo.

Bochdalek Jun. describes a NEW SMALL MUSCLE OF THE TONGUE, extending longitudinally in the middle line between the two genio-hyo-glossi (*Reichert u. Du Bois Reymond's Archiv*, Heft VI. 1866).

John Wood (*Proc. Roy. Soc. London*, June 21, 1866) and Alexander Macalister (*Proc. Roy. Irish Academy*, April 23, 1866) record numerous examples of VARIATIONS IN THE ARRANGEMENT OF THE MUSCLES OF THE HUMAN BODY.

REPORT ON THE PROGRESS OF PHYSIOLOGY from 1st July, 1866, to 1st March, 1867. By William Rutherford, M.D., *Demonstrator of Practical Physiology, University, Edinburgh.*

Physiological Chemistry.

Digestion. Bary (Hoppe-Seyler's *Untersuch.* i. 76), from researches undertaken with a view to ascertain whether or not the products of artificial digestion of albuminates are to be found in the stomach and chyle, has found that while peptone is always present in the stomach during digestion, parapeptone is generally absent. Like Lehmann he has failed to find either of these substances in chyle.

Blood. According to Hoppe-Seyler (Hoppe-Seyler's *Untersuch.* i. 133), the constituents of the tissues are oxidized outside the blood-vessels, and not after they have found their way into the blood, as maintained by Estor and Saintpierre. Moreover, Hirschman (*Reichert's Archives*, p. 502, 1866) opposes Estor and Saintpierre's view that CO^2 is formed in the blood. Hirschman maintaining from his experiments that it is formed outside the blood-vessels, and afterwards passes into the blood. Gwosdew (*Centralblatt*, No. 49, 1866) recommends the following process for obtaining hæmin crystals in great abundance. Dried and powdered defibrinated blood is mixed with one-fifth of its weight of pure carbonate of potassium, and is then digested with alcohol of 93 to 94 per cent. at a temperature of from 40 to 45°C.; the red solution is filtered, and the residue again extracted: the solution is diluted with more than its volume of distilled water, and rendered slightly acid by means of acetic acid: the colouring matter is then precipitated in brown flakes, which, when dried at 100° C., treated with one-fifth of its weight of chloride of sodium and 20 to 30 parts of glacial acetic acid, and then digested at 60° C., yields a solution which becomes almost completely transformed into crystals of hæmin.

Preyer (*Ann. der Chemie und Pharmacie*, cxl. 187) disapproves of the quantitative estimation of hæmoglobin by reckoning the amount of iron it contains, because the quantity of iron is extremely small, and the hæmoglobin of different animals may not contain an equal amount of iron. He moreover disapproves of Hoppe-Seyler's colorimetrical method of estimating it, owing to the difficulties which most persons experience in perceiving nice differences in colour. He proposes spectrum analysis, instead of the two above-mentioned methods. A measured portion of blood must be diluted with water until the green is visible in the spectrum. Such a solution is taken as the standard for future calculations, its strength is ascertained by referring to a solution of pure hæmoglobin of known strength. In order then to calculate the percentage amount of hæmoglobin in blood, it is only necessary to take a known quantity of blood, observe the extent of its dilution when the green becomes visible in its spectrum, and by referring to the percentage of hæmoglobin in the original standard solution to calculate the amount in the blood we may use. Perhaps for complete accuracy, the blood ought first to be saturated with oxygen. Preyer has found this method to be very exact. According to Hoppe-Seyler (Hoppe-Seyler's *Untersuch.* i. 140), protagon (see *Journal of Anat. and Physiology*, No. I, 161), together with cholesterin, is present in serum as well as in the blood corpuscles. Leucocythæmic blood contains it in great abundance. Protagon is also present in chyle in considerable quantity. Hoppe-Seyler supposes that it plays an important part in the formation of fats. His paper contains also some observations on cholesterin in blood.

Milk. Kemmerich of Bonn (*Centralblatt*, No. 30, 1866) has, under the direction of Prof. Pflüger, performed numerous experiments which confirm the theory advanced by Ssubotin—that butter is derived from the metamorphosis of nitrogenous principles. (See *Jour. of Anat. and Physiology*, p. 159.)

Muscle. Prof. Sczelkow (*Centralblatt*, No. 31, 1866) has found that the muscles of the wings of fowls always contain less creatine than those of the legs, and that the quantity is increased by tetanising the muscles. Nawrocki (*Centralblatt*, No. 40, 1866) has repeated these observations, and denies their accuracy. He finds the same amount of creatine in the muscles of the wings as in the legs, and finds that it is not increased by contraction.

Urine. Schunck (*Proc. Roy. Soc.* Nov. 1866) has obtained a small quantity of a crystalline fatty acid from human urine. He has not as yet determined its composition, but he inclines to the opinion that it is a mixture of stearic and palmitic acids. He has also ascertained that oxalurate of ammonia is a constituent of human urine, whether normal or abnormal however, his experiments are not numerous enough to enable him to say. He considers that its presence affords an

easy explanation of the appearance of oxalate of lime in urine long after its emission. This he considers due to the decomposition of oxaluric acid into oxalic and uric acids. He regards the oxidation of uric acid as the source of oxaluric acid in the body, just as it is found to be in the laboratory.

SOURCE OF HIPPURIC ACID. Meissner and Shepard (*Untersuchüngen uber das Entstehen der Hippur Saure im thierischen Organismus.* 8vo. p. 204. Hanover, 1866. Abstract in *Centralblatt*, Nos. 43 and 44, 1866), having entirely failed to find hippuric acid in the blood of herbivora, conclude that it is formed in the kidneys. This conclusion is supported by previous experiments of Meissner, who could find no hippuric acid in the blood even after the kidneys had been extirpated. After introducing benzoate of soda into the stomachs of dogs, they found benzoic acid in the blood and saliva, and succinic acid in the sweat; but hippuric acid could only be found in the urine. In opposition to Kühne and Hallwachs, they assert that they have satisfactorily proved that the conversion of benzoic into hippuric acid takes place quite independent of the liver. After injecting hippuric acid into the stomach of rabbits, they found extremely little hippuric acid in the blood, though abundance was found in the urine; on the other hand, benzoic acid and urea were abundantly found in the blood. When, on the other hand, hippuric acid was injected subcutaneously, hippuric acid was found in the blood in large quantities, but no benzoic acid. Hence it appears that hippuric acid is decomposed in the digestive tract into benzoic acid and glycocoll, the latter of which, according to Küthe and Horsford, is easily transformed into urea. Meissner and Shepard have found in the cuticle of plants a substance having the following formula $C_{14}H_{12}O_{10}$ which is nearly identical with the formula for cinchonic acid $C_{14}H_{12}O_{12}$. From this substance they suppose the hippuric acid found in the urine of the herbivora to be derived. They advance many other interesting speculations which want of space forbids that we should notice.

SOURCE OF FAT. Lawes and Gilbert (*Ed. Lond. and Dub. Phil. Mag.* XXXII. 439), from experiments on pigs, conclude that the fat stored up in their bodies is derived from the nitrogenous as well as the hydro-carbonaceous constituents of the food. Voit (*Versuchs-Stationen Organ*, p. 23, No. 1, 1866) supposed from experiments on the carnivora that the chief if not the only source of fat in the herbivora must be the nitrogenous constituents of their food.

GLYCOGEN. A notice of recent researches by Schiff (*Journal de l'Anat.* No. 4, 1866) on glycogeny has been given by Dr Foster at the close of his paper on Amylolytic Ferments, in the first number of the *Journal of Anatomy and Physiology*. Tscherinoff of Moscow (*Centralblatt*, No. 5, 1867) supposes that glycogen is formed in the liver from the sugar conveyed to it by the portal vein. So that according to him the liver is a sugar *destroyer* instead of a sugar *former*, as Bernard supposed. He ascribes diabetes to a diminution or loss of the sugar-destroying function of the liver. After the researches of Bernard, Pavy and McDonnell, it is not likely that this idea will receive much attention.

MYELINE-FORMS. Neubauer (*Virchow's Archiv.* XXXVI. 303) has found that the most beautiful so-called Myeline-forms, (rounded and elongated bodies with double contours, resembling nerve-tubes) may be produced by allowing a drop of ammonia to mix slowly with a drop of oleic acid.

SOURCE OF PULMONARY PIGMENT. According to Koschlakoff (*Virchow's Archiv*, XXXV. 17) all the pigment deposited in the lungs is derived from the colouring matter of the blood. Virchow (*ibid.* p. 186), on the other hand, alludes to cases where sharp-angled carbonaceous particles exactly resembling vegetable charcoal were found in the lung texture, leading to the belief that it had been introduced from without. So that, according to him, introduction from without, as well as origin from within, must be regarded as the source of the pigment.

EXCRETION OF CARBONIC ACID BY THE LUNGS. According to Lossen (*Zeitsch. für Biologie*, II. 244), the amount of carbonic acid exhaled by the lungs is much influenced by the depth of the inspirations. There is absolutely more carbonic acid excreted when slow and deep inspirations are taken, than when they are quick and short, although the amount of air respired in a given time be the same in both cases.

Nervous System.

BRAIN. Simonoff of Kasan (*Reichert's Archives*, v. 545) from experiments upon dogs has ascertained that the cerebral grey matter inhibits or restrains spinal reflex action. This had been previously ascertained to be the case in frogs by Setschenoff of St Petersburg (*Über die Hemmungs-mechanism für die Reflex thätigkeit des Rückenmarks*, pp. 80, Berlin, 1863). Leyden (*Virchow's*

Archiv, XXXVII. 519) has made a series of observations upon the movements of the brain, and the blood-pressure within the cranium by means of a manometer screwed into an artificial opening made in the skulls of dogs. Together with other interesting facts, he ascertained that when an animal is narcotised, the blood-pressure within the cranium increases pari passu with the appearance of the symptoms of narcotism. Dilatation of the pupil always followed a decided increase of the pressure.

MEDULLA OBLONGATA. Von Wittich (*Virchow's Archives*, XXXVII. 322), from researches upon frogs, concludes that the influences which produce respiratory movements never originate in the medulla oblongata as Rosenthal maintains, but always in the lungs or skin, from which sources they act automatically through the medulla.

SPINAL CORD. Dr Ingram Spence, (*Edin. Med. Jl.* July 1866,) from experiments on frogs, concludes that strychnia acts on a set of cells termed by him 'reflex' or 'intermediate' from their close connection with reflex actions. That these cells are not the motor-cells of the cord, he satisfactorily shews, but he gives no reason why they may not be the sensory cells. Gay of Rasan (*Centralblatt*, No. 4, 1867) has found strychnia in the grey matter of the spinal cord in animals which had been poisoned by it. The quantity found was proportionally greater, the slower the poisoning.

Circulation.

Dr Bever of Wurzburg (*Centralblatt*, No 53, 1866) confirms Von Bezold's observation that the cervical portion of the spinal cord is the great motor centre for the heart. According to Drs M. and E. Cyon, acceleration of the cardiac movements observed by Von Bezold to result from irritation of the cervical portion of the spinal cord is due, not only to irritation of the cardiac-branches of the sympathetic, but also to the increased blood-pressure, resulting from contraction of the small blood-vessels. The influence exerted by blood-pressure upon the rapidity of the heart's movements has not yet been ascertained. Bernstein of Heidelberg (*Centralblatt*, No. 1, 1857) says that as the pressure of the blood increases, the heart's action becomes slower, and that this effect is due to irritation of the roots of the vagi, as it does not ensue if they have been previously divided. On the other hand, Von Bezold and Stezinsky (*Centralblatt*, No. 52, 1866) maintain, with the brothers Cyon quoted above, that increase of the blood-pressure quickens the heart's action. According to Bever (*Centralblatt*, No. 53, 1866), section of the splanchnic nerves in the thorax acts like section of the cervical portion of the spinal cord in lowering the blood-pressure. These are the most important vaso-motor nerves in the body. Excellent papers on sphygmography, by Drs Burdon Sanderson, and Anstie, will be found in the *Lancet*, p. 517, and p. 688, 1866 and February 9, 1867.

Miscellaneous Observations.

EYE. Völchers and Hensen (*Centralblatt*, No. 46, 1866), by experiments on the eyes of dogs, confirm Helmhotz's theory of accommodation, thereby adducing evidence from the lower animals in its support. Adamük (*Centralblatt*, No. 36, 1866), by means of a manometer, the one extremity of which was introduced into the anterior chamber, has ascertained that the intraocular pressure is diminished by section of the cervical sympathetic; by atropin dropped on the conjunctiva; by opium, especially morphia, and by digitalin. The pressure is increased by extract of Calabar bean, introduced from the conjunctiva; by strychnia the ordinary pressure is doubled during tetanus; and finally by all irritants. Somewhat similar observations have also been made by Grünhagen (*Henle and Pfeuffer's Zeitschrift*, Dritte Reihe, XXVIII. 238).

LARYNX. Dr Wyllie of Birmingham (*Edin. Med. Jl.* Sept. 1866), in an elaborate paper on the Larynx, offers the following theory as to the function of the false vocal cords, and the ventricles of Morgagni. These cords by coming into apposition prevent the *exit* of air from the chest: the ventricles of Morgagni assist their closure just as the sinuses of Valsalva do that of the semi-lunar valves. The true vocal cords by their apposition prevent the *entrance* of air to the chest. He has demonstrated the above by experiments on the dead larynx and by laryngoscopic observations of the living. He also details numerous experiments which throw light upon the mechanism for the production of voice, which in order to be fully understood must be perused in the original.

CILIARY MOVEMENT. According to Kühne (*Schultze's Archives*, II. 372), if living ciliated Epithelium be placed in an atmosphere deprived of oxygen,

movement ceases, but is revived on allowing oxygen to enter. When placed in a solution of hæmoglobin they rob that substance of its oxygen. Carbonic acid stops the movements.

Spontaneous Generation. Experiments on eggs have led Donné to believe in spontaneous generation (*Comptes Rendus*, No. 7, 1866). Although in eggs which have been left to become putrid without the shells having been broken, Infusoria never appear, Donné thought that this might be due to the absence of pure air owing to vitiation of the air contained in the egg by the development of gases due to decomposition. In order to obviate this he pierced the shell while it was closely surrounded by cotton wool, which according to Pouchet entangles all the germs floating in the air, which may be passed through it. After this had been done infusoria always appeared in the egg, and Donné concluded that they had been generated spontaneously. Members of the French Academy doubted that Donné had taken sufficient precaution to prevent the entrance of germs from without. To satisfy these objections Donné threw a jet of boiling water into the opening in the egg in order to kill the germs (*Ibid.* No. 25, 1866), but notwithstanding this the Infusoria soon appeared. Pasteur objected to this that a temperature of 212° F., has been found by him insufficient to kill many infusorial germs. In reply to this Donné (*Ibid.* No. 1, 1867) pierced eggs with a stillette, allowed a little of the albumen to flow out, then filled the empty space with boiling water, and sealed the aperture in the shell; ere long, vibriones appeared in the fluid, and Donné concludes that the boiling water must at any rate have killed the germs of *vibriones*, and that consequently they must have been developed spontaneously from the organic matter of the egg.

Intestinal Absorption. According to Letzerich (*Virchow's Archives*, xxxvii. 232), fat and albumen are not absorbed by the epithelium of the intestine, but by vacuoles between the epithelial cells, which lead directly from the Intestine into the Lacteals. Fat in the epithelium he considers pathological and generally due to excess of fat in the food.

Action of Atropin. According to Von Bezold and Blöbaum (*Centralblatt*, No. 38, 1866), atropin paralyses the vagus without producing previous irritation thereof.

Action of Veratria. Von Bezold and Hirt (*Centralblatt*, No. 38, 1866) find that veratria first excites then paralyses the cardio and vasomotor centres. As has been observed in poisoning with Upas Antiar, so also under the influence of veratria, the auricles contract three or four times for every single contraction of the ventricles.

Action of Arsenic. Cunze (*Henle and Pfeuffer's Zeitschrift*, xxviii. 33) has found that if an animal be killed shortly after its getting a dose of arsenite of soda, not too large, the heart will continue to beat for a much longer period than it does under ordinary circumstances: this fact was observed even when the heart was removed from the body. He supposes that arsenic enables the tissues to resist more strongly the ordinary tissue-changes, and thereby to preserve their vitality longer.

Innervation of the Salivary Glands. According to Wittich (*Virchow's Archives*, xxxvii. 93), irritation of the cervical sympathetic in rabbits, cats, dogs and sheep produces increased secretion of a very fluid character from the Parotid gland, and simultaneously a tenacious fluid is secreted by the submaxillary gland. Eckhard (*Henle and Pfeuffer's Zeitschrift*, 3te Reike, xxix. 1), in opposition to Claude Bernard, maintains that the lingual ganglion does not serve as a reflex centre for salivary secretion, the only reflex centre for the submaxillary gland is in the brain. Moreover, from experiments upon the nerves connected with the parotid of the sheep, he concludes that 1st, the parotid of that animal secretes constantly; 2nd, the secretion is not controlled by any of the cranial nerves—he considers it doubtful whether or not it is even governed by the sympathetic.

Muscular System. Marey (*Journal de l'Anatomie*, No. 4, 1866) has ascertained by means of his myograph that each ventricular systole consists of a single prolonged contraction, and not of several short contractions, as is the case when a voluntary muscle is contracted for a period equal in duration to the systole of the heart. He adds the curious observation that a single contraction (e.g. that produced by closing or opening a constant current of electricity, transmitted through the muscle) of the voluntary muscles of the tortoise and crustacea lasts as long as the cardiac systole in mammalia. Von Bezold (*Centralblatt*, No. 38, 1866) has observed that in muscles poisoned with veratria a single contraction no longer follows the closing or opening of a constant galvanic current transmitted through them, but the muscles are thrown into a tetanic state. Helmholtz (*Verhandlungen d. Naturhist. Med. Vereins.* Heidelberg, iv. p. 88), finds that the normal muscular note produced by continued contraction consists of 18 to 20

vibrations in a second, instead of 36 to 40 as he formerly supposed. The note commonly heard is an octave above the fundamental note which is produced.

SOURCE OF MUSCULAR FORCE. Prof. Parkes (*Proc. Roy. Soc.* January 31, 1867), in an elaborate paper on "the elimination of nitrogen by the kidneys and intestines during rest and exercise on a diet without nitrogen," gives the results of an experiment performed by him on two soldiers, with a view to increase our knowledge on the subject indicated by the title of the paper. The experiment was virtually a repetition of that performed last summer by Fick and Wislicenus (see *Journal of Anat. and Physiol.*, No 1, p. 158), but he has taken care to meet the objections offered to their experiment by Prof. Playfair, at the last meeting of the British Association, that they had not estimated the nitrogen given off in the fæces, and that they had not continued the observations long enough in the period of rest which followed the period of work; for he suggested there might have been a vicarious elimination of nitrogen by the intestine, and the nitrogen might have been retained in the system during the work, and discharged some time afterwards. Parkes has shewn that neither of these possibilities occurs. He took two healthy soldiers, and kept them for six days on their ordinary diet and occupation. He examined the composition of the urine daily, and ascertained that in both cases the constituents were pretty constant in their proportions: he moreover estimated the intestinal, cutaneous and pulmonary egesta, and these together with the urinary egesta, when compared with the food taken, and the weight of the body at the commencement and at the close of the experiment, shewed "that the tissue-changes in both cases were very closely the same, and that therefore the men were comparable and well fitted for the experiments." He then kept them for two days, in a state of perfect rest, upon a non-nitrogenous diet. He ascertained the amount of food taken in this period, and the amount of nitrogen excreted by the kidneys and intestine. During a third period —which lasted four days—the men returned to their ordinary food and occupation, in order that the system might regain its original state. During this period it was observed that the total amount of nitrogen excreted was during the first three days less than that excreted during the first period, when the other conditions were the same. The amount of nitrogen excreted during this third period gradually increased from the time when the non-nitrogenous diet was abandoned, and only attained its normal amount on the fourth day, thereby shewing that nitrogen had been retained in the system to supply the place of that which had been excreted when no nitrogenous food was being taken. A fourth period extended over two days during which they performed work upon a non-nitrogenous diet: during this, as compared with the second period, the nitrogen excreted by the kidneys and intestine was found to be slightly increased. As regards the Urea, during the first thirty-six hours of this period, it was found to be below the amount excreted in the corresponding period of rest, but it rose somewhat above that amount during the last twelve hours of the fourth period, which was the night after a walk of 33 miles (on the previous day they walked 22 miles). Lastly, the men were kept under observation for four days after their return to their ordinary diet and work. Again, as in the third period, the nitrogen excreted by the kidneys and intestines gradually increased, as had been observed in the after-rest (third) period. It was found however that rather more nitrogen was excreted during the four days of the fifth than during the four days of the third period, but this slight increase was accounted for by the increased quantity of nitrogenous food taken during the fifth period. The conclusion from this experiment then is, that muscular work performed on a diet without nitrogen increases to a very slight extent the amount of nitrogen eliminated by the kidneys and intestine, and unless the nitrogen be found to disappear through the skin we shall be compelled to conclude that in such cases, if not in all, muscular force is derived from the metamorphosis of carbo-hydrates.

DEVELOPMENT OF STRIATED MUSCULAR FIBRE. Eckhard (*Henle and Pfeuffer's Zeitschrift*, Dritte Reihe, XXIX. 56) agrees with Savory, Lockhart Clarke, and F. Schulz that striated muscular fibre is not developed from cells but from a nucleated blastema. This conclusion is also supported by Braidwood (see *Journal of Anat. and Physiology*, No. 1). All agree that the fibres are formed from the molecular matter in which the nuclei are embedded. Eckhard has also made observations on development of the heart of the chick, and states that at no period can cells be seen, but here, as in the muscles of the skeleton, the earliest stage is a nucleated blastema which rhythmically contracts before fibres make their appearance, the latter are developed from the internuclear matter directly. Lockhart Clarke had previously pointed out the fact that the development of the cardiac muscular fibre is the same as that of the voluntary muscles.

NOTICES OF RECENT DUTCH AND SCANDINAVIAN CONTRIBUTIONS TO ANATOMICAL AND PHYSIOLOGICAL SCIENCE. By W. D. MOORE, M.D., Dub. et Cantab.; M.R.I.A., &c., &c.

I. *Nogle Bemærkninger om Befolkningsforholdene med særligt Hensyn til Antallet af mandlige og quindelige Individer.* Af. Prof. Dr Faye. Aftryck ur '*förh. vid de Skand. Naturf. nionde möte ar* 1863.' (Stockholm, 1866.) Remarks upon the proportions of the population, with special reference to the number of male and female individuals, by Prof. Faye, M.D.

In Sweden, where accurate statistical records have been kept during the last 105 years, the number of females to that of males is as 109 to 100. Wappæus, giving the average of $58\frac{1}{4}$ millions of human beings, found that 106·33 living boys were born for 100 girls, and a much greater preponderance would be met with if death struck both sexes in equal proportion in the womb and during birth. But other reliable statistics have shewn that for 1000 still-born females we have from 1346 to 1449 still-born males. During the first years of life, too, the mortality is greater on the male side. The Professor does not think the disproportion is accounted for by differences in the ages of the parents, as has been supposed by Hofacker, Sadler and Leuckart. See more extended report of this part in *Brit. and For. Rev.*, April 1867.

II. *Nederlandsch Archief voor Genees-en Natuurkunde onder medewerking van* P. Q. Brondgeest, M. Imans, A. P. van Mansvelt *en* H. Snellen, *uitgegeven door* F. C. Donders *en* W. Koster. Utrecht, 1866. Dutch Archives of Medicine and Natural Philosophy, by F. C. Donders and others.

1. *Bijdrage tot de kennis der Bloedligchaampjes*, door J. G. van der Lith, M.D. Deel II. 2e Aflevering, p. 186. Contributions to our knowledge of the blood-corpuscles, by J. G. van der Lith.

The chief object of this paper is to call attention to the hypothesis of Donders and Moleschott, respecting the mode of development of the blood-corpuscles in the Frog. These physiologists examined the blood of frogs which had been kept without food for various periods, and, in addition to the red blood-corpuscles, found nucleated cells and free nuclei, the last especially being in greater number the longer the animal had been kept without food. Hence they correctly look upon these nucleated cells as blood-corpuscles in a state of retrogression, and of which at last the periphery disappears, leaving only the nucleus. Lith considers that the view entertained by Wharton Jones, Ecker, Kneuttinger and others, that these nucleated cells are young blood-corpuscles, presents many difficulties. A more detailed account of this paper is given in *Dublin Quart Jl. of Med. Sc.* xliii. 249.

2. *Over de structuur van de terminal-streng van den nervus sympathicus en van het peripherisch gedeelte dezer zenuw*, door G. J. Luchtmans. *Ibid.* p. 219. On the structure of the terminal cord of the sympathetic nerve, and of the peripheral portion of that nerve, by G. J. Luchtmans.

In accordance with Bidder and Volkmann, and in opposition to Kölliker and Valentin, he attributes distinctive characteristics to the sympathetic fibres: viz. their greater fineness; their accordance with wavy connective tissue, perhaps in consequence of their softness causing the fasciculi to adapt themselves in form and course to the neurilemma, which consists in part of wavy connective tissue; and the inequality and irregularity of the reticulum surrounding their nerve tubules. He finds that the ganglionic globules, with their nuclei and nucleoli, are smaller than those in the spinal ganglia. With regard to the spinal nerves he thinks that the sensory have a smaller diameter than the motor nerve-fibres, and that the sensory roots alone contain sympathetic fibres.

3. *Onderzoekingen over de histiologische zamenstelling der vlokjes van het darmkanaal* door Dr J. A. Fles, *Ibid.* p. 221. Investigations respecting the histological structure of the villi of the intestinal canal, by Dr J. A. Fles.

His method of investigation consists in tying some of the well-filled lacteals, and of the arteries and veins of the mesentery in dogs and cats, fed or not with fat. The portion of intestine, the vessels of which are tied in this manner, is also tied, opened between the ligatures, washed out with water at 98° F., and then filled with a tolerably (?) strong solution of chromic acid. The part thus prepared is cut out beyond the ligatures, and placed in chromic acid. At the end of from three to six weeks the preparation is ready for examination. The villi are then firm, and present so much resistance, that, with a good razor,

transverse and longitudinal sections can be made. These are placed in glycerine or in dilute acetic acid. We have in such preparations the vessels injected with their natural contents coagulated. The author gives, as a conclusion from his investigation, that the lacteals in the villus possess in their lower two-thirds a proper wall, lined with epithelium, towards the apex of the villus, however, the boundary of the cavity is formed by a network of the finely fibrous stroma, which constitutes the basis of the villus. The meshes of this network are large enough to allow chyle corpuscles or colourless blood-cells to pass through, which accordingly are seen throughout in the interspaces of the stroma of the villus (adenoid tissue). The author thinks therefore that in the villi colourless blood-cells are formed, and in absorption are carried away with the fluids taken up. He found the central lacteal of the villus, after feeding the animals with fat, filled with fatty emulsion and colourless blood-cells. A layer of muscular fibres, a continuation of the muscular coat of the intestinal wall, is found around the lacteal. The extremities of the epithelial cells of the surface of the villus are connected, not with connective tissue corpuscles, but with the fibrous stroma. As to the nature and signification of the striæ, perceived under a high magnifying power at the basal end of the epithelial cells, the author can, from his investigation, offer no decision.

4. *De Sarcine* (Sarcina ventriculi, Goodsir), *onderzoek naar de plantaardige natuur, den ligchaamsbouw en de ontwikkelingswetten van dit organisme,* door Dr W. F. R. Suringar, Hoogleeraar te Leiden. *Ibid.* p. 222. The Sarcina ventriculi (Goodsir): an investigation concerning the vegetable nature, the corpuscular structure and the laws of development of this organism, by Dr. W. F. R. Suringar, Professor at Leyden.

The author comes to the conclusion, that the reaction of the sarcina-cells with Schultz's test, which indicates the presence of cellulose in the cell-wall, decides their vegetable nature; while as yet no reason exists not to consider the sarcina as an independent species. Robin had looked upon the sarcina as a kind of merismopoedia, but the cell-division takes place in these algæ not in three directions, while it does so in the sarcina. Virchow had already investigated the vegetable nature of the sarcina, but had failed to obtain the reaction of cellulose. Suringar succeeded in this, having discovered that the cells must first be treated with caustic potash or with nitric acid. The parasite therefore retains the name of *Sarcina ventriculi* (Goodsir). It is to be considered as settled that it produces no morbid symptoms, and that its occurrence is not connected with definite diseases of the stomach. We find it in the healthy and in the sick, also in the intestinal canal, in animals too, rabbits, fowl. A second species seems to occur in the urine. Heller, Hepworth, &c., and subsequently Welcker, have found sarcinæ in human urine. Rosman described the sarcinæ found by Welcker more accurately, and points out a constant difference in the magnitude of the cells of gastric and urinal sarcinæ. The latter are smaller by one half. Though further observations are desirable, Suringar is inclined to look upon the urinal and gastric sarcinæ as not identical, but as two different species.

The author's further investigations respecting the structure and mode of development refer exclusively to the sarcina ventriculi hominis. It appeared to him that what is described by Robin as *one* cell, is a bundle of eight cells, each provided with a cytoblast. Robin's cell, with a depression in the centre, and partitions extending thence in four directions, is therefore a compound cell-mass; what he called the four nuclei are independent cells, each of which, by partitions in three directions, speedily become again bundles of eight cells. In what was called nucleus by Robin (proper contents of cell), Suringar could, by using a high magnifying power with favourable light, distinctly demonstrate the cytoblast. By elongation and division the nuclei for the eight new cells are produced from the cytoblast.

Division takes place by the development of three partitions perpendicular to one another. The development of these partitions regularly follows the same laws, but one is always somewhat further advanced than the other, so that in consequence of a greater extent of the surface in which the most developed partition lies, the cells are seldom purely cubic but prismatic.

The regular tracing of the formation and growth of the partitions, and at the same time of the cells themselves, and the observation of the time which elapses from the beginning to the end of a complete cell-division, have enabled the author to establish the laws of growth and multiplication in a mathematical form.

5. *Aaneengroeiing van niet correspondeerende zenuwvezelen, na intercranieele doorsnijding van het vijfde paar.* Door Dr B. Rosow en Dr H. Snellen.

Ibid. Deel II. 3rde Aflevering, p. 348. Growing together of non-corresponding nerve-fibres, after intercranial division of the fifth pair. By Dr B. Rosow and Dr H. Snellen. The authors had entered upon a series of experiments as to the influence of the nerves upon the conditions of pressure of the eye, but had arrived at no positive results. Some observations, incidentally made, appeared to them, however, not devoid of interest, and among these, one of a remarkable regenerative process in the divided nervus trigeminus. From the results of their experiment they infer that the hitherto so-called neuroparalytic inflammation of the eye after division of the trigeminus, is to be considered as traumatic keratitis.

On the 24th December the right nervus trigeminus was divided, in the usual manner, in a full grown rabbit. Measures were taken to preserve the eye from injury. On the 18th January the animal was exhibited before the Physiological Society of Utrecht: the whole right side of the eye was absolutely insensible. The cornea was normal. The vessels of the eye externally visible were not perfectly dilated. The fundus oculi, examined with the ophthalmoscope, presented nothing remarkable; the retinal vessels were not different from those of the other eye. The pupil was somewhat narrower than that on the other side, and it reacted to strong light. It was found that equal quantities of atropia, introduced into the eyes, produced equal mydriatic action in each. An opposite experiment with calabar four days later, likewise proved in every respect equality of the eyes.

"24 January: Insensibility continues, eye sound, but there is considerable subcutaneous accumulation of pus around the eyelids in the situation of the sutures fastening the cover for the protection of the eye. It was determined to remove the cover. The following day the conjunctiva was red, there was excretion of mucus; the cornea was uneven from the exfoliation of epithelium.

"On the 26th January the eyelid-slit was quite covered and closed with dried mucus. This was carefully soaked away. We now found the cornea turbid; the inferior third of it was completely infiltrated and white, and superficially softened. Only in the upper part was the cornea still so transparent that the iris and the margin of the pupil could be seen. The suppuration of the sutures in the skin had meanwhile nearly disappeared.

"We have here in 33 days after division of the trigeminus, merely by no longer protecting the eye from injury, completely obtained the neuro-paralytic ophthalmia of earlier science. We now proposed, by curing this 'neuro-paralytic' ophthalmia, still further to prove the correctness of our view. The cover was anew placed before the eye, and was not again left off. The good eye was repeatedly cleaned. Even on the following day the congestion was diminished, and the cornea presented a more favourable appearance. With strict cleaning alone, without the employment of any remedy, the affection of the cornea was completely removed. On the 15th February a small spot remained on the inferior portion. The pupil was somewhat contracted. In the middle of March a small piece of the cornea was cut out, in order, under these circumstances, also to trace the process of regeneration. Hereupon violent reaction ensued, keratitis with great vascular formation, so that on the lower surface of the cornea a complete pannus was developed. On the 1st April the cornea was again transparent, and in the middle of that month all irritation had ceased, and the ophthalmia had left behind it only a slight spot.

"During these observations a very accurate investigation was repeatedly instituted as to the continuance of the insensibility of the eye and of the surrounding parts. On the 27th January an interesting phenomenon in this respect was, for the first time, observed. Up to that date, the whole of the right half of the face had continued quite insensible. The cornea, conjunctiva, upper eyelid, and supra-orbital region were still quite insensible. On strongly pinching a circumscribed part of the under eyelid, not the slightest reaction of the eye and eyelids now ensued, but, on the other hand, remarkably enough, constantly a movement of the mouth precisely as in chewing. At first it was thought whether this phenomenon might be accidental; but upon irritating the same place several times consecutively, precisely the same chewing movement invariably arose. The animal meantime remained otherwise quite apathetic. It moved no other lid, and even for the strongest pinching of the part did not draw the head back, so that it seemed that the irritation of this circumscribed place, which reacted so peculiarly, produced no unpleasant sensation in the animal. This phenomenon continued, and can even to day (3 months later) be exhibited most satisfactorily several times consecutively.

"The state of the animal was again exhibited before the Physiological Society on the first of May: with the exception of a slight spot on the cornea the eye

was quite well. The whole bulb, the upper eyelid, and the whole upper half of the right side of the face, including the nasal cavity, were insensible. On irritating the under eyelid the chewing movements above described always took place; the part formerly circumscribed had therefore extended over the whole right lower half of the face. Contrary to what had been before observed, this place now appeared to be hyperæsthetic: very slight irritation, even slight pulling of the eyelashes, produced the chewing movement, and stronger irritation was apparently disagreeable to the animal, as thereupon it quickly drew back its head.

"No other explanation of this last phenomenon is conceivable, than that the peripheral nerve-branches have coalesced with the central ends of the nerve-fibres, previously connected with the cavity of the mouth, so that now upon irritation of the eyelid a sensation arises in the mouth. The mechanism of the intracranial division of the trigeminus renders it very possible that the two extremities have in some manner been pushed into opposition to one another. In other cases of neurotomy, also, the growing together of non-corresponding nerve-fibres has been witnessed.

"This case is undoubtedly interesting with respect to the question of the nutritive influence of the trigeminus. The unquestionable coalescing of non-corresponding nerve-fibres proves, in a very absolute manner, the completeness of the division of the nerve, and still the eye continued, in the absence of any traumatic cause, perfectly healthy. Moreover the traumatic keratitis, twice produced, got well precisely as we see occur where the sensibility is unimpaired. We have thus a confirmation of the result of the experiments of H. Snellen, related in an Inaugural Dissertation, 1857, p. 27: *that division of a nerve produces no essential change in the process of inflammation.*" *Dubl. Quart. Journ.* xxviii. 449.

6. *Over de zelf-regeling der dierlijke Warmte.* Door Jacobson en Landré, Candidaten in de geneeskunde aan de Utrechtsche Hoogeschool, (*met voor en naschrift* van F. C. Donders.) *Ibid.* p. 355. On the self-regulation of animal heat. By Jacobson and Landré, Candidates in Medicine in the University of Utrecht. (*With introduction and appendix* by Professor Donders.) Professor Donders suggests that cold-blooded and warm-blooded animals might be better classed as animals of inconstant and constant temperature. The former follow the temperature of the surrounding medium, the heat which they develop at most maintaining them a little above it. Their life is possible, though on a low scale, at a temperature at which they nearly freeze, as well as in the greatest heat of summer, to which they are exposed. The latter, and especially man, live with a still greater difference of external temperature; but the temperature of the internal parts remains tolerably constant, and great deviations in most cases soon remove the conditions of life. Bergmann and the writer, independently of each other, recognised in the skin the moderator of animal heat, and found that in its vaso-motor nerves the self-regulation of the latter takes place.

In many animals some parts of the surface of the body are specially adapted to act as moderators. In the dog, the paws, nose, and especially the tongue; in the ape certain parts of the face; in cocks and turkeys the vascular combs and gills, which usually have a low temperature, but under particular circumstances become very warm; in the rabbit, Schiff has discovered a phenomenon in the ears, which makes their part in the economy of animal heat plain enough: viz. the periodical contraction and dilatation of the vessels, which, as Professor Donders saw with van der Beke Callenfels (*Dissert. inaug.* Utrecht 1859), on conveyance into a cold temperature give way to permanent contraction, and into a warm to permanent dilatation,—in the former case with warm, in the latter with cold ears. The theory which places the moderators of heat in the skin, in rabbits more particularly in the ears, had as yet received but little experimental confirmation; to supply this in some degree is the object of the researches of HH. Jacobson and Landré. The details of their experiments upon rabbits, are given in a number of tables; the results of these, they observe, prove that the persistently elevated temperature of the ears, which is the result of the division of the sympathetic nerves, gives rise to cooling of the body, which gradually recovers, while increased metamorphosis of tissue meanwhile diminishes the weight of the body. They show further, that, other things being equal, the variations of the animal heat are greater, when the semiparalytic condition of the vessels of the ears interrupts their action as moderators of the same.

7. *De phonautograaf, een middel tot bepaling van de absolute quantiteit der vocalen*, door F. C. Donders, *Ibid.* 4de Aflevering, p. 466. The phonautograph,

a means of determining the absolute quantity of the vowels, by Dr F. C. Donders, F.R.S., Professor of Physiology and Ophthalmology in the University of Utrecht. This communication conveys further observations (see page 173) on the vibrations and curves belonging to the consonants and vowels, as determined by the phonautograph of M. Scott.

8. *Over de bepaling der dierlijke warmte bij puerperaal-processen*, door Prof. L. Lehmann. *Ibid.* p. 470. On the determination of the animal heat in puerperal processes, by Prof. H. Lehmann. The observations were made in a great number of cases, and the part selected was the vagina, which in non-pregnant women gave 98° F.; during pregnancy 99°; during parturition 104°; immediately after delivery 100°; on the 2nd or 3rd day 102° to 105°.

9. *Geleidingsbanen in het ruggemerg voor de gevoels-indrukken, volgens onderzoekingen op verschillende diersoorten*, door Dr H. Sanders Ezn. 1866, *Ibid.* 3de Aflevering. p. 379. Paths of conduction in the Spinal Cord of sensory impressions, deduced from investigations on different species of animals, by Dr A. Sanders Ezn.

The result of his experiments of isolating the posterior columns of the spinal cord, and transversely dividing the remainder in Frogs, is (in opposition to those of Brown-Séquard and Van Deen, and to some extent in conformity with those of Schiff) that sensory impressions, the effects of the stronger sensory as well as tactual stimuli, are conducted longitudinally by the columns. He finds also that sensory impressions are very freely conducted in the grey matter, those from either side passing through any part of it. He believes, with Deiters and others, that the fibres of the posterior roots all pass into the grey matter; and he thinks that the route of the impressions after traversing the grey matter is in part, at any rate, through the posterior columns.

M. Robin, *Journal de l'Anat.* Jan. 1867, in an elaborate paper on the LYMPHATICS of the Torpedo and other Plagiostomous Fishes, shows that there are no superficial lymphatics in these animals, the vessels supposed to be such by Monro and others being veins. The description of the relations of the lymphatics to the blood-vessels is generally in accord with Professor His' account of the (perivascular) spaces formed by the former around the latter. He regards the endosmotic force in the membrane of the blood-vessel separating the blood from the lymph, to be the main agent in promoting the flow of lymph rather than any contractile action of the lymphatic vessels; and he remarks that this structure of the lymphatics suggests that the lymph is derived not from the disintegration of anatomical elements, as muscular fibre, &c., but from the blood itself, and that their principal function is to carry off the excess of the blood-plasma.

Dr Onimus (ibid, p. 47, Expériences sur la GENÈSE DES LEUCOCYTES et sur la GÉNÉRATION SPONTANÉE) endeavours to prove, 1. The spontaneous production of anatomic elements in amorphous blastema, in opposition to the views of Virchow. 2. That vibrios are produced by heterogeneous generation in the serosite from a blister and from the white of egg, if the molecular actions and processes of endosmose and exosmose be allowed to take place, even though germs be absolutely excluded. The experiments were made by taking the serous fluid from a fresh blister, in which state it is free from colourless corpuscles (leucocytes), and placing it in gold-beater's skin and then introducing it under the skin of an animal.

M. Perez gives in the *Annales des Sc. Nat.* a very elaborate description, traced through all the stages of its life-circle, of a species which first appeared under the generic name of Vibrio, then as Anguillula, then as Rhabditis (Dujardin), and adds some interesting remarks on the cellular theory of embryology.

M. Edouard Gouriet has contributed an interesting paper to the *Annales* (Dec. 1866) on the function of the SWIM-BLADDER of fish. His experiments were made upon living fish of several species (tench, carp, roach and gudgeon), and consisted of: (1) the puncture and emptying of the air-bladder; (2) the section throughout its length of the circular cincture of muscles by which the fish was supposed to compress the bladder; (3) by this process conjoined with the complete removal of the bladder. In all cases the fish could gain the surface at pleasure, and had no difficulty in sustaining itself in that position. From these and other experiments he concludes that the swim-bladder is only an accessory swimming organ. Its volume continually varies during ascent and descent, but

the fish does not need to exert any volition to accomplish this, as the variable pressure of the column of water effects it. In fact, the function of the swim-bladder is not indispensable, and is purely passive.

These experiments, conjoined with those communicated by M. Monoyer in April, in which he showed that the distension of the swim-bladder tended to increase the instability of the already unstable equilibrium of the fish, and was in no sense a locomotive organ, seem completely to overthrow the ingenious theory connected with this organ, which once received implicit credence.

Professor Burt Wilder gives (*Proc. of Boston Nat. Hist. Soc.*, May 1866) an instance of a cat with 7 toes on one fore foot, and 6 on the other, and 5 toes on each hind foot. The supernumeraries were all on the radial and tibial borders. He regards them as instances of simple vegetative repetition, and considers it unsafe to attempt to determine morphological relations by reference to parts so liable to variation from vegetative repetition as are the terminal segments of the limbs.

The results of Philipeaux's studies on animal grafting and on the reproduction of the spleen in mammifers and of limbs in aquatic salamanders (*Annales*, Jan.), may be summed up thus:

The spleen which has been removed, when replaced in the abdomen sometimes reunites by its hile to the mesentery and continues its function. If the spleen be completely cut away no reproduction occurs; but if a part (three-sixteenths of a mouse and one-tenth of a rabbit) be left it is gradually reproduced. If the whole limb, including the scapula, be removed from a salamander no reproduction occurs; but if shaved off close to the body, the whole limb, with its twenty-three osseous constituents, is reproduced.

M. Plateau (*Annales*, Jan.) shows, by experiments, that the typical eye of a fish is equally suited for vision in air and water as far as distant objects are concerned. For near objects (non-parallel rays) the focal length is shorter in the air than in the water. Amphibious animals (mammals, birds, reptiles, &c.) have eyes approximately like fish, they therefore, as well as fish, can see both in a watery and aerial medium, while the greater adjustment to variable distances necessary to vision in the air is supplied to amphibious animals by the aid of the ciliary muscle.

M. Claparede, in a note on the reproduction of Aphides (*Annales*, Jan.), confirms the view of M. Mecznikow, that in Aphides we have a case of AGAMO-GENESIS, and combats that of Balbiani, who maintains that the intermediate aphis is hermaphrodite. The difference turns upon the character of a green cellular mass to which the blastoderm gives birth, and which is in juxtaposition with a colourless cellular mass which the authors call respectively ovary and pseudovarium. The first-named aggregation of cells is called a testis by Balbiani and a supplemental vitellus by Mecznikow.

Dr Voisin and M. Liouville (*Journal de l'Anatomie*, Avril 1867) found the effects of CURARA to be an augmentation of the force and frequency of the pulse, increase of the internal temperature, in the number of inspirations, and of the urinary secretion (which contains sugar); in stronger doses, disturbances of the circulation and of the power of voluntary motion, hyper-secretions, and derangements of the cerebral and visual functions. These symptoms are so exactly characteristic of fever, that the authors conclude that the action of fever must be identical with that of the poison. Curara acts on the motor nerves, especially on the vaso-motor branch of that system, the nerves of sensation being unaffected. Death ensues from this cause alone, muscular irritability remaining intact. The opinion that the poison is innocuous when taken into the alimentary canal, because it is eliminated by the liver before it reaches the general circulation, is confirmed.

Dr J. B. Sanderson's purpose, in the Croonian Lecture for 1857, ON THE INFLUENCE EXERTED BY THE MOVEMENTS OF RESPIRATION ON THE CIRCULATION OF THE BLOOD, was to show the incorrectness of the statement usually made that the frequency of the pulse is lowered and arterial tension diminished during inspiration. He shows, on the contrary, by experiments made upon dogs that the immediate effect of inspiration, as well as of expiration, in natural breathing, is to increase both force and frequency of the heart's contractions; and even during dyspnœa caused by partially plugging the trachea the force and frequency of the pulse were increased by the prolonged inspiratory efforts of the animal.

In the interval or pause between the thoracic movements, which is about two-thirds of the period occupied by the respiratory act, the force and frequency of the pulse declined. This effect of inspiration is entirely mechanical, and is due to the influence of the thoracic expansion aiding the expansion of the heart during diastole and of the thoracic veins; for, other things being equal, the force and frequency of the contractions of the heart are increased by whatever causes accelerate its diastolic impletion. *Proc. Royal Society*, March 1867.

Brücke recommends the following method of preparing a "soluble Berlin blue" for transparent injections.

Dissolve 217 grammes of ferrocyanide of potassium in 1 litre of distilled water. Dissolve 10 grammes of Ferric chloride in 1 litre of distilled water. Prepare a cold saturated solution of sulphate of sodium. Mix one volume of the ferrocyanide solution with two volumes of the soda solution, and also one volume of the iron solution with two volumes of the soda solution. Pour the iron mixture gradually into the ferrocyanide mixture with constant stirring, and let stand for some hours. Pour off the supernatant liquid and filter off the deposit. Wash the deposit with *small* quantities of distilled water until the filtrate runs through quite blue. Press and dry.

The blue powder thus prepared is readily soluble in distilled water. To a concentrated solution of it add only just so much gelatine as will ensure the mixture setting in a jelly. Immediately after injection throw the object into spirit, and let it remain there for 24 hours. Cut it into pieces and harden in 90 p.c. alcohol.

The sections at first often appear to have lost their colour, but are readily revived by being soaked in turpentine, especially in turpentine which has for some time been exposed to the action of air. They may then be transferred to Canada Balsam, or to a turpentine solution of Dammara. This injection bears chromic acid and bichromatic of potash well, but all fluids containing glycerine must be carefully avoided.

Cohnheim and Köllicker strongly recommend the use of chloride of gold for demonstrating various points in histology. Tissues which have been soaked for some time in a weak solution of it, and afterwards exposed to light are found to exhibit certain parts, ex gr. nerve-fibres, connective-tissue corpuscles and cells in general, stained of a bluish, violet, or reddish colour, while other parts ex gr. intercellular substance &c., are untouched. The fresh tissue should be covered with a little of a solution of from 1 to ·2 per cent. of chloride of gold in distilled water (the strength must be made to vary according to the thickness of the object and other circumstances), and allowed to stand until it assumes a straw-yellow colour. It should then be washed and placed in very dilute acetic acid (1 to ·2 per cent.). The colour will in the course of some hours gradually develope itself. Nerve-fibres and connective-tissue corpuscles are exceedingly well shewn by this method, which will probably come into very general use as a sort of correlative of the "silvering" method with dilute solutions of nitrate of silver. As a general rule what the silver stains the gold does not, and *vice versa*.

Professor Huxley, who, during the months of February and March, has been delivering the Hunterian Course of Lectures at the Royal College of Surgeons on the *Sauropsida*, or group composed of *Reptilia* and *Aves*, laid before the Zoological Society on April 11th the results of his researches into the Cranial Characters of Birds in regard to their affinities and arrangement.

After some general remarks on the virtual identity of structural principle between Reptiles, especially the *Lacertilia*, and Birds, and maintaining that the latter did not form a class in the sense that *Mammalia* do, Prof. Huxley said that in casting about for some character which might guide him to a natural classification of birds, he had come to the conclusion that this was most completely furnished by the structure and arrangement of the different bones forming the palate. Why this was he did not pretend to offer a suggestion; it was a fact to be ascertained by observation. He then proceeded at considerable length to point out the variation of structure and arrangement observable in the different groups of birds, which might be disposed, he said, into *three* Orders: (I) the *Saururæ* of Heckel, the existence of which was proved by the unique specimen of that marvellous form *Archæopteryx;* (II) the *Ratitæ*, composed of a small number of

forms, Ostriches, *Apteryx*, and their allies; and (III) the *Carinatæ*, which includes all the remaining extant birds. The *Carinatæ*, he said, might be separated into four well-marked groups or sub-orders: (i) *Dromæognathæ*, (ii) *Schizognathæ*, (iii) *Desmognathæ*, and (iv) *Ægithognathæ*. The first of these comprehended only the New World family *Tinamidæ*, in which the cranial characters were entirely those of the *Ratitæ*, or, to speak more precisely, of the genus *Dromæus*. In other respects their structure was very generally that of Gallinaceous birds. The second sub-Order, *Schizognathæ*, was made up of six groups, which led on from one to the other imperceptibly, and might be named, (1) *Geranomorphæ*, (2) *Charadriomorphæ*, (3) *Columbidæ*, (4) *Alectoromorphæ*, (5) *Cecomorphæ*, and (6) *Squamipennes*. Among these birds would come the Cranes, Bustards, Plovers, Snipes, Doves, Poultry, Gulls, Petrels, Auks, and Penguins. They all had the roof of the mouth cleft in such a manner that the blade of a knife might be passed forward freely on either side between the vomer and the palatal bones. In the third sub-Order, *Desmognathæ*, to do this was impossible, the knife was at once stopped by a bony bridge: this group including Birds of Prey, Parrots, nearly all the *Picariæ* of Nitzsch, the *Anatidæ*, Flamingoes, Ibises, Storks, Herons, and the *Pelecanidæ*—he sub-divided into seven groups as follows: (1) *Raptores*, (2) *Ginglymognathæ*, (3) *Picariæ*, (4) *Chenomorphæ*, (5) *Hemiciconiæ*, (6) *Pelargomorphæ*, (7) *Steganopoda*. The fourth sub-Order had a palatal arrangement and structure somewhat intermediate between the second and third. This, the *Ægithognathæ*, comprehended by far the largest number of genera and species of birds, and might be divided into two groups, (1) *Cypselomorphæ*, comprehending the Goat-suckers, Swifts, and Humming Birds, and (2) *Passeres*, comprising all the groups not hitherto named, and surpassing them all put together in number. They are distinguished by a remarkable uniformity of general structure; however, in some of them, as in certain Finches, was apparent a superficial resemblance to the structure of the palate in the Parrots (*Ginglymognathæ*).

Prof. Huxley then explained more at length his scheme of classification as given below:—

Order { I. Saururæ. / II. Ratitæ. / III. Carinatæ. }

i. Dromæognathæ.	ii. Schizognathæ.	iii. Desmognathæ.		i. Ægithognathæ.
	3. Geranomorphæ	8. Raptores.	13. Ginglymognathæ	
	2. Charadriomorphæ			
	7? Columbidæ		14. Picariæ	15. Cypselomorphæ
1. Tinamomorphæ	6. Alectoromorphæ	9. Chenomorphæ		
	4. Cecomorphæ	10. Hemiciconiæ		
	5. Squamipennes	11. Pelargomorphæ		16. Passeres
		12. Steganopoda		

Prof. Newton being called upon by the Chairman (Dr Gray), expressed his general assent to the results at which Prof. Huxley had arrived, but not altogether to the manner in which they had been reached. He thought Prof. Huxley had fallen into the fault of nearly all systematists, and had assigned too much importance to one single character, whereas he (the speaker) believed that a natural arrangement could only be made out by taking an aggregate of characters. In particular, he thought the variable value of the palatal character was shewn by the first and last cases mentioned by Prof. Huxley. The Tinamous, which had the Emeu's head, being in almost every other point truly Gallinaceous, and the Grosbeaks, which were most undeniable Finches, though they possessed palatal characters in common with the Parrots, for which fact possibly the relation between structure and habit should be assigned as the reason. However, Prof. Newton did not for a moment doubt the propriety of Prof. Huxley's views in most cases, and was especially pleased to find his own opinions, which he had been many years forming, and which (drawn chiefly from a consideration of the characters of the sternal apparatus) were confirmed in a very singular manner by the statements of his learned friend, to whom he was sure Ornithologists were most sincerely indebted for putting their science on a more reasonable footing.

Mr W. K. Parker, F.R.S., insisted on the high value of cranial characters. He went further than Prof. Huxley did on the Tinamou question, for he would not like to separate the group from the Ostriches, though it had a keel to its sternum.

Prof. Huxley had no prejudice in favour of the palatal characters. Their importance had forced itself on his own observation, and their solution was entirely an empirical process. It was very difficult to obtain an aggregate of characters. In answer to an observation by Mr Sclater, F.R.S., that the changes he proposed were not so very violent, he shewed on the paradigm how totally subversive they were of the Cuvierian arrangement.

The Chairman observed that in his opinion internal characters were of little use in Zoology.

NOTE ON COPULATION IN SPIDERS.—It is now generally thought that the maxillary palpi of the male spider are the distributors of the sperm, and that these organs are alone concerned in the fertilization of the female. Even at the present time, however, the subject is considered by many to be *sub judice*, and therefore it is desirable that all carefully made observations on this point should be duly recorded. The following too is particularly valuable because it was made on a species of the genus Epëira, while most of the important observations which have previously appeared have been made on Lycosæ or Tegenariæ.

At noon on September the 17th, I was standing at an open window looking over the Fellows' Garden at Caius College, when my attention was attracted by a large female Epëira on a web in the corner of the window. By her side a detached spider's leg was hanging. This at once suggested to my mind an encounter between the sexes. Upon looking round for further evidence I found clinging to a thread at some distance below a small spider apparently of the same species. This I found was a male, and on closer examination I observed he had lost one of his hindermost legs. Presently he climbed up and round to the margin of the web at the point nearest to the female: here he attached a thread which he spun out and fixed near the place he had before occupied. This line he went over backwards and forwards two or three times, strengthening it and taking up all threads impeding his course. Then, after jerking the thread from below several times, he climbed up, and approached the female. She remained perfectly still until he was almost within her reach, then started forward and made a grab at him: he, however, saved himself by beating a hasty retreat. Then the female moved off to another part of her web, and he again went through much the same process. During an hour and half this was repeated over and over again—he continued perseveringly to spin threads to approach her conveniently, but all to no purpose, for as soon as he neared her, she put him to flight, and then moved off to another part of the web. But towards the close of this period, a change gradually came over her, she allowed him to approach her and submitted to be stroked by him with one of his foremost legs. At first he did it very warily, as it always ended by her pouncing at him, and his having to escape for his life; but the resistance became more and more feeble, and at the completion of an hour and half from the time I first observed them, he succeeded in effecting a union. This he accomplished very suddenly, but with no resistance on her part, in fact she aided him by her position. The period during which they remained united could scarcely have been more than three or four seconds, but it was sufficiently long for me to observe that the male had its maxillary palpi, side by side, firmly pressed down (as if attached) just in front of her spinerets, while his abdomen projected over her cephalothorax. He disunited as suddenly as he took up his position, and had only just got out of her grasp (for during the consummation her legs were stretched out all round him) when she snapped at him as before. But he got safely out of her clutches and went feebly off to a retired corner, and there he was resting when I looked out for him half an hour afterwards. The female walked off to the centre of her web and there remained on the alert for prey.

Mr Blackwall[1], our great English Arachnologist, in his paper read before the British Association, gives a lengthened and even more graphic account of observations made on Tegenaria civilis and several species of Lycosæ, and these prove beyond a doubt that the palpi of the male are, in these genera at any rate, frequently thrust into the vulva of the female. He states, moreover, that "the sexes of Lycosa lugubris sometimes continue paired more than four hours; during which period the male applies the palpal organs several hundred times to the vulva of the females." Surely this looks as if the opinion of Treviranus was correct, that these organs are used for excitation preparatory to the actual union of the sexes. But Mr Blackwall considers that these observations, taken together with those he next records, are conclusive in showing that the male does fertilize the female by means of his palpi. These next experiments were rather strange ones. Females of Tegenaria civilis were submitted to solitary confinement for

[1] Report of the Fourteenth Meeting of the British Association.

eleven months, at the end of which period males whose genital apertures had been previously papered over were admitted. The males at once applied their palpal organs, and shortly afterwards they were removed, but the females, as in the other experiments, commenced in a few weeks, for the first time during their captivity, to lay fertile eggs; but it must be noticed that in one case a female continued to lay fertile eggs for two years and a quarter afterwards. The females on which these experiments were made were kept in glass phials. Now, I cannot help thinking, that so artificial a state of existence might cause constitutional disturbances sufficient to render them temporarily barren, but when they had become accustomed to their confinement the extra stimulus might be sufficient to make them again fertile. At any rate, considering how frequently spiders lay batches of eggs, and considering that this female Tegenaria, during the two years and a quarter, laid no less than nine batches of eggs all fertile, it is hard to understand on any other hypothesis why the female laid no eggs for eleven months. Still, I must allow that Mr Blackwall's evidence is very strong indeed, though I cannot consider it, as he does, conclusive. One experiment occurs to me which, though it would not be altogether satisfactory, might give important results. It is this: the male spider in some cases ought to have been turned in upon the female after he had had both their palpal organs removed.

Formerly these palps were considered to be simply intromittent organs. This idea, however, was given up when anatomists failed to find any orifice in their extremities. Then the notion was started that these organs were used to collect the sperm from the abdominal aperture and to hold it in readiness for rapid distribution to the female organs. This is the view held by Mr Blackwall, but I believe we have no evidence of the first part of the performance from any eyewitness. To make the experiments where the male organs were covered more perfect the spiders should have been kept for a considerable time without being able to get at the source of the sperm, before the females were admitted. The case recorded by Mr Blackwall where the spiders remained "paired" for four hours shows that the palps are not special provisions for rapid fertilisation to save the male from too close contact with the ferocious female—a point which Professor Owen insists upon. If these organs are really used for fertilisation I think we must search again for a seminal duct in their interior. In the allied class, Crustacea, among the Brachyura we find organs known as false feet, whose office was for a long time disputed, and no less an authority than Milne-Edwards[1] declares "ces appendices paraissent devoir servir à diriger les verges vers les vulves, et peut-être aussi à exciter ces derniers organes."

However, in 1850, Mr Spence Bate[2] stated that he had several times "taken Carcinus mœnas in the act of copulation, under which circumstances," he says, "I distinctly saw these styliform processes deeply inserted within the vulvæ of the female." Mr Bate also pointed out for the first time the existence of a vas deferens in these false feet. Among these animals copulation lasts for at least a day or two, perhaps for a considerably longer period. In the case, however, which I have recorded, it is clear to my mind that the maxillary palpi were applied for the purpose of holding on, and applied in a definite manner, so that the male and female genital apertures came into apposition rapidly. In many classes of animals we have instances where appendages appeared to be specially modified in the male for the purpose of holding on during sexual union. Such a provision is seen in the foremost feet of the male Dytiscus, in the antennæ of the male Daphnia, and in the 'claspers' of the male shark. Now accessories of this kind appear to be particularly necessary where the intromittent organ is absent or where that organ is merely temporised. It might be urged that Epëira has *scopulæ* and *sustentacula*, which organs would be amply sufficient for holding on, but, for this particular office, I think it can scarcely be doubted that these modified palpi would be far more serviceable. Viewing the whole subject in a Darwinian point of view, it is obvious that natural selection might give rise to a breed of spiders where the intromittent organ was extremely short or even absent, for it is certain that if the male had this organ of any length it would not live to perform its duties a second time; and it has been proved that spiders live through several years. But it is not equally easy to understand how so important a function should be handed on to other appendages which could not at that time have been prepared for the office. Such a change could not have been sudden, so perhaps two methods of fertilization still exist among spiders. There are some species of Araneæ where the swellings at the end of the male palpi do not exist. These species should be carefully studied.

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[1] *Histoire des Crustacés*, Vol. I. p. 169.
[2] *Annals and Mag. of Nat. Hist.* Vol. VI. Second Series, p. 109.

INDEX.

M.

N.

O.

P.

END OF VOLUME I.

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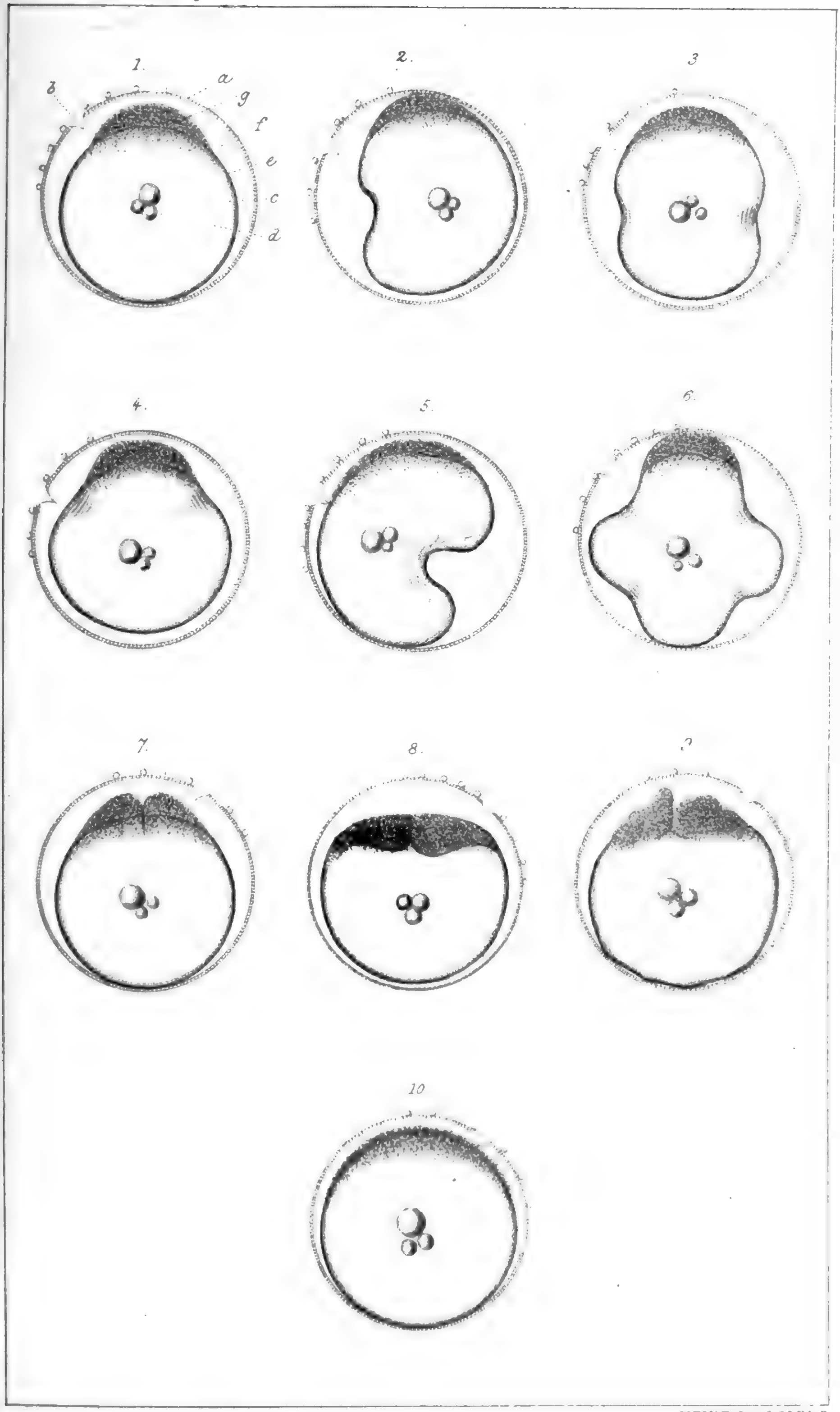

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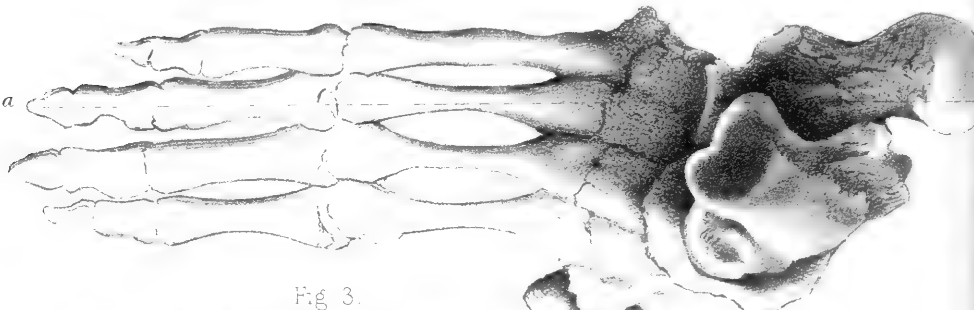

Fig. 3.

Fig. 4.

Fig. 5.

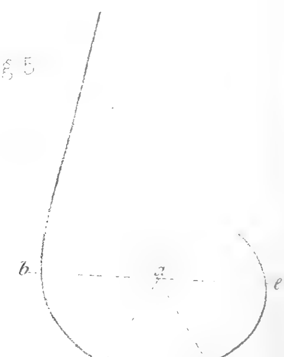

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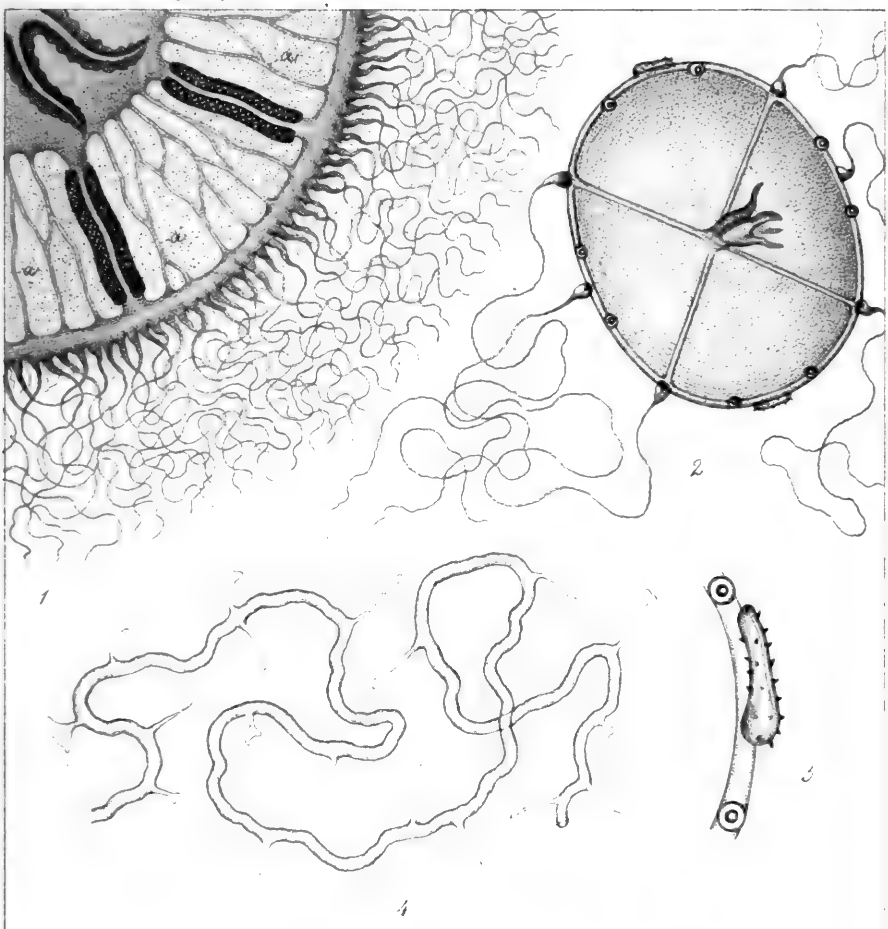
Fig. 6.

Z. F. F. p. 268



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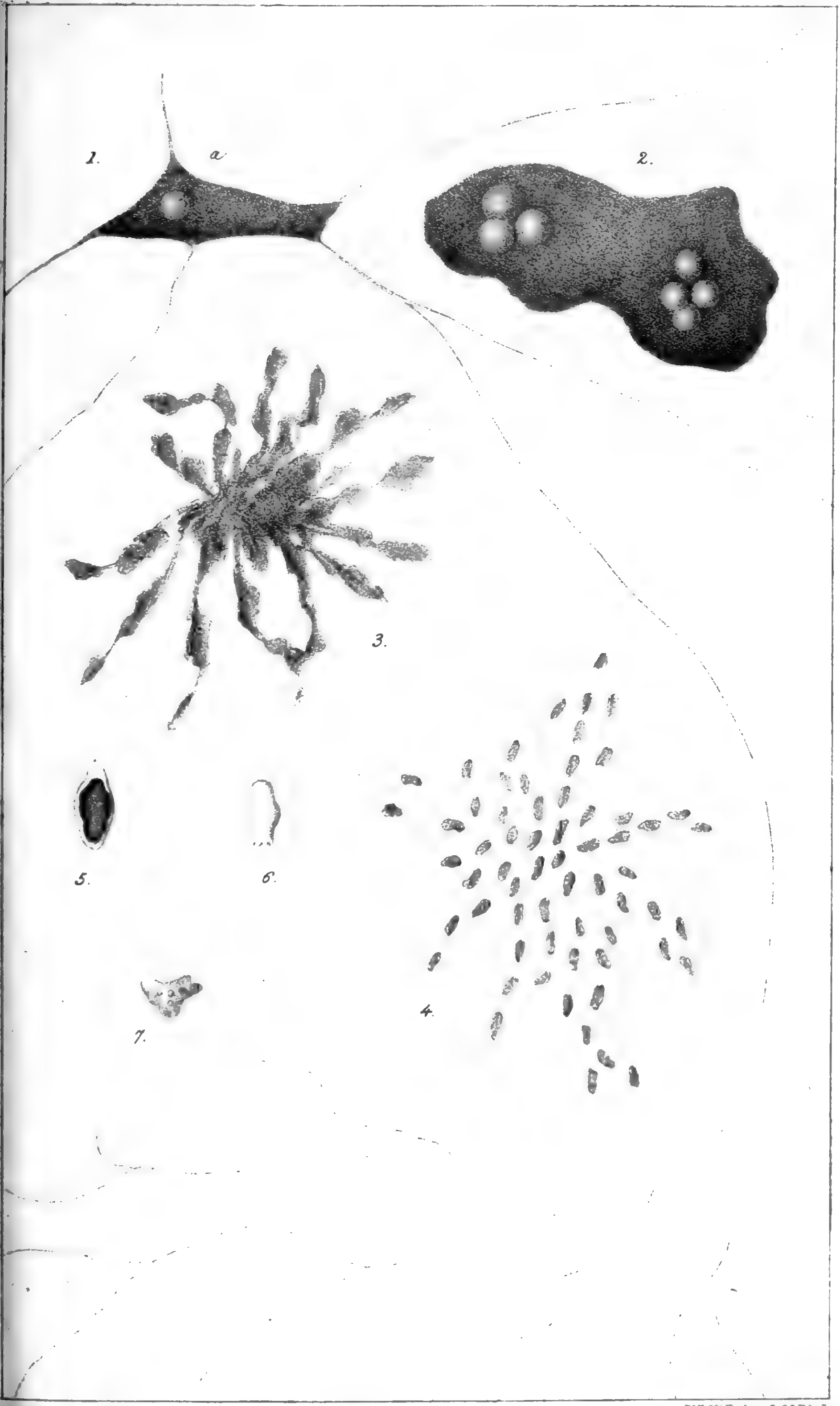

W. H. McFarlane, Lithr Edinr

BODERIA TURNERI.

9